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STATE OF NEW YORK

SIXTH ANNUAL REPORT

OF THE

COMMISSIONERS

OF THE

State Reservation at Saratoga Springs

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TRANSMITTED TO THE LEGISLATURE JANUARY 6, 1915

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J. B. LYON COMPANY, PRINTERS
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No. 9

IN SENATE

JANUARY 6, 1915

Annual Report of the Commissioners of the State Reservation at Saratoga Springs

To the Honorable the Legislature:

The Commissioners of the State Reservation at Saratoga Springs respectfully make report of their proceedings since January, 1914.

In their report of that date they made urgent request for the appropriation of the sum of $350,000 to provide funds for the acquisition of additional properties then known to be needed and to provide for the deficit in the original appropriation caused by the accumulation of interest and expenses incident to acquisition, amounting to more than $100,000. They also made urgent request for the appropriation of the sum of $100,000 to carry forward vigorously "the further investigation and expert study of the various aspects of the problem committed to this Commission and for the proper maintenance, administration and protection of the properties taken and the supplying of free service to the public."

Of the $100,000 requested, only $10,000 was provided by the passage of an emergency act. The remainder of $90,000 was reduced in the Legislature to $50,000, an appropriation bill for which sum passed both houses but was vetoed by the Governor. In place of the $350,000 requested to provide for the deficit as above

stated and the acquisition of further property, $235,000 of bonds were appropriated for the general purposes of the Reservation as set forth in the request for $100,000 above referred to and for the acquisition of property and for the deficit.

This reduction of $205,000, or nearly half of the necessary amount requested by the Commission, has seriously impeded the work of the Commission during the past year. They were, in consequence, unable to make acquisition of certain properties of the first importance to the proper development of the Reservation, nor were they free to plan for such vigorous prosecution of the work of development as was desirable because they thought it necessary to hold in reserve funds to meet any unexpected emergency.

This emergency actually arose when the European war so suddenly developed conditions that will, it is believed, hasten and greatly increase the demand for the fuller and more varied use of the mineral waters of Saratoga Springs. The provision of additional facilities for baths then became the most urgent claim upon the Commission.

The improvements in the one small bath house owned by the State, formerly known as "The Magnetic Bath House," were made as proposed in the last annual report, so that the limited facilities offered there were brought in line with the better modern practice which our investigations disclosed. This is now called "The High Rock Bath House," as more in accord with the facts of the case, and also as having a proper historic relation to its location and to the source of the mineral water used in these baths. The bath business during the last summer showed an increase of 40 per cent over the previous season, which was very satisfactory in view of the moderate equipment. This plant was leased to Mr. Oscar R. Stenstrom, who is technically well equipped and has given much satisfaction as a practical bath director.

Mr. Stenstrom also leased the "Saratoga Baths" from the owner, Mr. Harry M. Levengston, with an agreement to utilize therein the State waters under the supervision of the director and the engineer of the Reservation. This agreement gave opportunity for acquiring valuable additional knowledge of the conditions and enabled the Commission to make necessary experiments and observations. The knowledge thus acquired will be of the utmost serv-

ice and advantage in preparing plans for the construction of the new bath house. The Commission are now convinced that it is of immediate importance to the State that this property known as the "Saratoga Baths" should be acquired as a part of the Reservation. It is so situated with reference to the mineral springs and the property where the principal bath house should be constructed as to make it most necessary to the completion of the State's purpose in developing these waters. They believe the State fortunate in that the Commission have secured from Mr. Levengston an offer to sell this property to the State for an amount which is considerably less than half the sum it cost him to build it. The acceptance of this offer will also settle the claim of Mr. Levengston against the State for mineral water rights taken in 1911. The engineer of the Commission finds it practicable to bring this plant up-to-date in its equipment for giving mineral water baths by a moderate expenditure for the necessary improvements. The Commission respectfully urges that at a very early date funds be provided to take advantage of the option to purchase this property, so that the improvements required to put it in proper condition may be completed by the month of May. The amount necessary to improve this property is included in the request of the Commission for the appropriation of $75,000 for maintenance, improvement and development. This amount is an increase beyond the $59,000 named in the budget submitted in November to the Comptroller, because the option from Mr. Levengston was secured after the date when it was necessary to file the budget with the Comptroller.

Very many indications have convinced your Commission that there will be a great number of people desirous of taking the mineral water cures in Saratoga Springs during the season of 1915, provided there are the necessary facilities. These people have heretofore been in the habit of taking such cures in the European resorts, and will be unable for various reasons to visit such spas in 1915, whether the war shall continue or not. This probable demand seemed to your Commission of such imperative character that they deemed it obligatory upon them to utilize for additional facilities the building of the Lincoln Spring Company, which was acquired when that property was taken by the State as necessary to the control of the mineral water basin and to stopping the pump-

ing of the waters for the separation of the gas from them. The building is a good wooden structure, being 205 feet in length, with steam boilers and smoke-stack already installed, so that it offered an opportunity to develop, at a minimum expense, facilities for accommodating several hundred patients a day with mineral baths. The construction will, of course, be simple and economical; but it will be good and of the most approved type as regards the hygienic and therapeutic efficiency of the equipment. It is the judgment of the Commission that this utilization of the building and the mineral waters in the ground around it would in any case have been desirable at an early date in order to provide accommodations at the lowest prices possible for the great population of farmers, artisans and others, who would not be able to avail themselves of the luxurious facilities necessary to be provided for those who are accustomed to take the cures in Europe. A fine quality of pure non-mineral water is also available in the upper strata of the land surrounding this building. The equipment therefore will include swimming pools and full use of the fresh water as well as the mineral waters. The building is situated in what is known as Lincoln Park, of the State Reservation, about sixty acres in extent, including some six acres covered with a mature growth of pine trees which provide the very desirable adjunct of groves, carpeted with pine needles, where patients can take the Oertel exercises, which are an important factor in the bath treatment for arterial and heart affections. The preparation of the necessary roads and paths and the planting to make this park a proper environment of the bath house have been pushed as rapidly as possible during the fall, and the results warrant the assurance that during the coming season there will be an attractive surrounding to an excellent bath house, which will enable those who may come to receive in comfort the benefit of the healing waters the State has acquired. The whole outlay for this equipment, including the fresh water plant and pumping station, and two swimming pools, one for men and one for women, will be within the sum of $25,000. During the fall the bulk of the land in this park has been forested, and paths and roads lined with larger trees. In one portion of the tract alfalfa will be planted next spring, it being the judgment of certain practical farmers that the soil is promising for such a crop and

that its utilization at this point may become an important object lesson to the citizens of the State in connection with the nearby Nursery of the State Forestry Department located in Geyser Park of this Reservation, which annually provides some millions of pine and spruce transplants for farmers and others.

The reasons given above for the immediate equipment of this building add emphasis to the urgent recommendation of the Commission in the report of last year that the State appropriate a sufficient fund to build a first-class modern bath house that shall be thoroughly up-to-date in every particular and in all respects able to compete with the attractions offered in foreign resorts. The Commission has placed in their budget a request for the sum of $350,000 to construct now a portion of such a bath house, to be of one-half the size of that which in their judgment it will be necessary for the State to have in due time. The Commission did not have funds to acquire the entire block which they deem to be necessary for such a bath house, but were able to acquire at a low figure one-half of the block, located immediately opposite the beautiful village park (Congress Park); and it is on this half-block that it is proposed to construct a portion of the new bath house. The Commission were without sufficient funds to prepare the plans and model of the bath house needed, as was recommended in last year's report. The engineer of the Commission has, however, prepared preliminary plans for the portion of the building now proposed, and the State Architect will it is hoped prepare a perspective drawing of said building, so that the Legislature may be able to appreciate the more readily what is suggested. It is not recommended that the Commission shall be confined to this preliminary suggestion, but that they shall be free to take advantage of the fuller study of this problem which will be given by the architect, who shall later be chosen by the State Architect. They cannot too strenuously urge that there be no delay in making the appropriation for this construction, as they deem it important that the foundations and walls of this new structure should be under process of erection during the summer of 1915.

There has been acquired during the year only a small part of the additional property needed by the State because of the lack of

available funds. It is due to Miss C. L. Huston, of Philadelphia, that this formal acknowledgment should be made by the Commission, of her noble public interest in making purchase at her own risk, in the fall of 1913, of the half-block of ground now held by the State for the proposed bath house. The Commission was without funds at that time to acquire the property, which was then obtainable at a low valuation, and feared the purchase by interests that might begin the construction of buildings that would result in largely increased cost to the State at a later date. This property is so manifestly a part of the proper site for the bath house, that it was a notable gain to have this risk eliminated. Miss Huston made no profit whatever, but was at considerable inconvenience during the many months of ownership, before the property was taken over and finally paid for by the State.

Other small properties acquired enabled the completion of the connection between the Lincoln Park and the Geyser Park tracts, by the construction of a promenade sixty feet in width, extending one mile in a straight line. This promenade bas been planted with four rows of white pine trees and is to be reserved for pedestrians and for occupants of wheel-chairs, where the necessary exercise and open air may be obtained, away from the usual dust of road travel. A property of about six acres, needed for the above and to complete the Geyser Park entrance and to enable the closing of a second grade crossing of the four railroad tracks through the park was acquired. The cost of these properties and some ten acres, completing the Lincoln Park, will be moderate, as the values are small.

A small tract adjoining the Geyser crossing of the Delaware & Hudson R. R. tracks has been acquired as the location of the necessary storage house for bottled waters to which the R. R. side tracks can have direct access for loading. This is convenient for both the Geyser Central Bottling Works and the Soft Sweet Spring Bottling Plant. Also several parcels of farm lands necessary properly to protect the water supply of important springs will be acquired shortly. These aggregate some fifty acres of moderate value.

The State also acquired the property adjoining the Favorite Spring on Broadway and adjacent to the Hudson Valley Trolley

Terminal. This property was necessary for the proper development of the park and terminal to be constructed and maintained by the Hudson Valley Company in connection with a lease negotiated by the Commission with said company, which lease is conditional upon proper track connections being authorized by the village. In the judgment of the Commission this use of the property is the best for the interests of the State; but, if it should be prevented by the failure of the village authorities to give the necessary consents, it would be the only property owned by the State at all available for the construction of the Drink Hall, which is essential to complete development. Its present size is not large enough for the Drink Hall, but it could be enlarged if no other site were obtainable. The property is also of undoubted commercial value if the special public use above suggested should not develop.

The remaining small property acquired is that containing the United States and Pavilion Springs which, under the control of the State authorities, are already showing improvement in their mineral contents as a result of the restoration and protection by the State of the mineral water basin. The mineral water rights of the small property adjoining, known as the Royal Spring, have also been acquired.

There are other properties now known to be important to the future development of this Reservation, which, in the judgment of your Commission, should be acquired at an early date in order to protect properly the mineral water basin and to make improvements which it is now clear are essential to establish permanently the full use of these waters and a suitable health resort. The budget submitted asks for $350,000 to cover these and the purchase of the property known as the Saratoga Baths, above referred to.

This report has already grown to a length greater than the Commission like to inflict upon the Legislature and they, therefore, briefly report that the properties of the State have been maintained at as small an expenditure as possible. All the various springs have received attention and some few have been retubed, as shown in the accompanying report of the engineer. The Hathorn No. 2 and Coesa Springs, which are at the southernmost end of the

Reservation, have been connected with the Geyser Building by means of wooden pipes. The Orenda Spring is also connected with this building, in which the Geyser and Minnonebe Spring waters were already being bottled, so that the handling of the State mineral waters is concentrated here. This building is close to the side track of the Delaware & Hudson Company; and this will assure the bottling of these waters at a point where the expense of cartage of bottles and materials and of the cases of bottled water to the railroad will be considerably lessened.

Having thus concentrated the bottling of these naturally carbonated waters, the Commissioners are now able to determine that the State will have a considerable supply of surplus carbonic acid gas, which it will be able to dispose of after the bottling of these waters. It is probable that there may be an income of several thousand dollars per year from this source, increasing as the surplus of gas from other wells is collected. Anticipating such an opportunity for profit the Commission, in removing the structures in Geyser Park, retained one gasometer and one gas compressing plant. Negotiations are now under way, and it is hoped that within a few weeks a contract may be made for the collection and disposition of this surplus gas on satisfactory terms.

In order to recover the waters of the original Congress Spring, a new bore is now being drilled under the direction of our engineer, Professor Anthony, who found the old bore out of the vertical and closed by pipes fastened in it. It is believed that this difficulty may prove a blessing in disguise as better and more reliable access will be secured to the vein from which this most famous mineral water was taken. It is hoped that by the early part of the new year the drill will reach that vein and that we may then report the recovery of the Congress Spring. In view of the experience of the slow return to their original strength of the Hathorn and other waters, it is assumed that when first recovered this spring will perhaps be only half its ordinary strength, but we have no doubt that in time the Congress water will regain its full strength and become one of the most widely distributed of the State's waters and again prove of very great value and profit.

The lease to Hathorn & Company has been continued on the same terms. Although terminable on ninety days' notice, which

precluded much advertising, the results during the past year show a fair increase in sales, and profits increased 50 per cent. One-half of the profits, reserved for the State, sufficed to cover the cost of the free service to the public provided by Hathorn & Company under the terms of the lease and also improvements on the State property authorized by the Commission. The Commission have continued the bottling and sale of the mineralized table waters from the Geyser and Minnonebe Springs, with constant study of the problems connected with the maintenance of the proper equilibrium between the gas and mineral contents, which it is hoped are now solved.

The proper marketing of the waters requires large capital, with ample funds provided for advertising. It had been the expectation of the Commission that the summer of 1914 would prove the proper time to advertise both in Europe and in the United States for bids to lease for a long period the privileges of bottling and selling these waters. The European war, however, altered the situation completely, and no steps have as yet been taken in that direction. It now proves well for the State that there was delay because during the fall months, the Engineer and Chemist were able to develop several exceptional springs of pure non-mineralized water, without gas, which should be put on the market. The analyses made of this water demonstrate that it ranks with the purest drinking waters known and the practical use which has been made by many families and by physicians proves that it makes strong appeal to the taste; in fact, all who have used it are most enthusiastic as to its qualities and the desirability of having it properly marketed. The demand for such water is universal, some of the well known still waters that are marketed being shipped to both Europe and Asia, besides being widely distributed throughout hotels and private residences in the United States. It is believed that the proper handling of this water should prove in its way as great a benefit to the public as will the restoration and wide distribution of the mineral waters. It seems clear that there should accrue a very large profit from the proper development of this additional business, as the gross sales of such waters aggregate millions of dollars each year. With the seal of the State of New York on the label, and the guarantee of the regular

analysis by the State Chemist in the Laboratory of the Commission showing its purity, it should easily take first place among such waters. It has been named "The Saratoga Soft Sweet Spring Water." These springs are located in the Geyser Park where the purity of their waters will be thoroughly protected. The Commission have begun the construction of a bottling plant of the most approved style, which should provide for such demand as may develop during the next two years, and enlargement of the plant can readily be made. The group of springs will be developed in the most attractive manner for proper observation, as it is located close beside one of the paths in the Geyser Park which will be frequented by great numbers of visitors throughout the year. There is every reason to believe it will, in this way, advertise itself extensively.

The current business of the Commission in the maintenance of the State property and the care and development of the same and the organization of the engineering staff, with the necessary office force to further the limited advertising propaganda, has been one of much variety and continual pressure. It has called for unremitting attention at all hours from a staff quite too limited in numbers, because of the very strict economy, even called by some parsimony, which the Commissioners deem necessary to be practised. The Commission think it proper, therefore, to make reference to the great devotion to the interest of the State shown by all who have been associated in this work.

During the year the chemical laboratory has been organized, to take charge of which we secured Mr. Herbert Ant, an experienced chemist, who was in the Department of Health at Albany for several years. The work of this laboratory will become continually of more interest and importance.

The Engineering Department will have, for some time to come, a great amount of detail to handle in connection with the varied work which the Commission must undertake, and especially in connection with the studying out of possible improvements upon the plans of other State and municipal establishments of like character. Each new development confirms the Commission in their realization of the good fortune of the State to secure at the proper time an engineer of such experience and facility in mechanics as

also in engineering as Professor Charles G. Anthony, who has devoted to this work a considerable amount of his time as consulting expert, doing much supervisory work as well.

A year's further experience has made it clear that it would have been difficult for the Commission to have proceeded effectively with their work had it not secured the services of one so variously equipped by special experience as Dr. Albert Warren Ferris, the director, has proved himself to be. It was of vital importance to have constantly at hand some one upon whose ability, experience and character they could unquestionably rely.

We record with utmost emphasis the inestimable value to the State of the services rendered by the Hon. C. C. Lester during the past year, not merely in his capacity of legal adviser but because of the wholehearted manner in which, from the very beginning, he has placed his great information respecting local conditions and his scientific knowledge of the problems encountered at the command of the Commission and its staff.

The Commission accepted with regret the resignation of Mr. Irving G. Rouillard, as secretary, who left in May to take up the course of study for his chosen profession. We deem the State fortunate to secure, as his successor, Mr. Louis W. Noland, who had been for some twelve years associated with the Poland Water Company. Mr. Noland's knowledge of the business of distributing waters has proven of great importance at this particular time in the development of this feature and should be increasingly valuable to the work.

All additional facts and knowledge which the Commission are able to secure more than confirm their confidence in the great and assured usefulness and large profit of this Reservation of waters taken by the State. These are, of course, wholly dependent upon the proper development by the State of the properties acquired and others now known to be necessary, so that they shall be made as attractive to those in search of health or recreation as other like resorts. Success is necessarily bound up with the ability to deal with the problem broadly and generously as any business organization would do. The Commissioners ask for three-quarters of a million dollars to be appropriated this year for the purposes set forth

in this report. They have restricted themselves to this sum because of the emphasis that has been placed upon the condition of the State finances. They feel bound, however, again to call the attention of the Legislature to the methods used by governments in Europe and private corporations in the United States in developing such resources. Their practice is to provide ample funds at the beginning with which the proposition may be treated broadly.

It is understood that recent important developments at Greenbrier Springs in West Virginia have involved an expenditure in excess of $1,000,000 for improvements and attractions offered. Your Commission have had many comments respecting the contrasts between the methods of developing property based on a few springs in a community distant from the centres of population, and the very limited appropriations made by the State of New York to develop what is concededly the greatest collection of mineral springs anywhere to be found. There is in Saratoga every opportunity for beautiful landscape development at a very moderate expense, and the appeal for such outlay is certainly as strong as could be made. The Commission further recite, and again, as illustrating the competition the State must meet, the appropriation by the City of Harrogate, England, of one and three-quarter millions of dollars for improvements of its spring property; by the City of Wiesbaden the sum of one million for a new bath house; by the Kingdom of Bavaria of one and three-quarter million dollars for improvements at Bad Kissingen; by the City of Carlsbad of about two and a half million of dollars; and the appropriation made in the spring of the year 1914, by the City of Aachen (Aix la Chapelle) ten millions of marks, or nearly two and a half million dollars for additional improvements to their bathing facilities, so famous for a century past. All of these bathing establishments pay handsomely. The Commissioners are confident that it would be the truest economy for the Legislature to provide now, in one appropriation, the sum of two million dollars to be used by the Commission, so far as needed, for the prompt and full utilization of the resources of the State in the property already taken and for acquiring other property now known to be needed, and for the construction of proper buildings and the necessary landscape treat-

ment in connection with the development of the grounds and parks. Three Commissioners are to be appointed by the Governor in January, when the terms of the present Commissioners expire; and every known fact calls for their being put in control of ample funds to enter upon a wise, farsighted and prompt carrying forward of this extremely important work of conservation. The present Commissioners cannot too strongly urge the very early consideration of this matter as one quite apart from the ordinary question of appropriations for the expense of the Government and one that special conditions, created by the great war in Europe, make more urgent now than heretofore.

We recommend most earnestly the early and favorable consideration by the Legislature of the items submitted in the Budget for appropriation in a Special Bill:

For the acquisition of additional property.....	$350,000
For the construction of a suitable modern bath house including power house, of one-half the ultimate size, on the half-block on Spring street now owned by the State.....	350,000
For maintenance, development and improvement of the Reservation property, including advertising, and the work of the engineering and other departments, preparations of plans, etc.....	75,000
	$775,000

The Commissioners beg to express their hearty appreciation of the many courtesies and cordial co-operation extended by the Commissioner of Health and his deputy and the various members of the staff of that most important department of the State. They also beg to express their sense of obligation to the Hon. Lewis F. Pilcher, State Architect, for his considerate attention to and counsel upon problems of construction which the Commission presented to him. They make record of the enthusiastic expressions of the Governor respecting his recognition of the importance of this work of conservation.

The Commissioners submit herewith the reports of the superintending director, the engineer, the chemist, and the secretary, all of which reports they urge that the members of the Legislature will read with care.

They will also submit later, appended to their report, a study of the hydraulics of the Saratoga mineral water system, written by their counsel, Hon. Charles C. Lester, embodying some of the results of scientific interest and practical importance attained by means of the investigations they have instituted and the data they have collected since they undertook the creation and administration of the State Reservation at Saratoga Springs.

The accounts for December and the year will not be completely made up until the middle of January, but the Secretary will give herewith summaries of the financial record of the year.

They beg to call attention again to the matter of the deficit of over $100,000 deducted from the fund for the acquisition of lands, for expenses incident to their acquirement, and for interest. This deduction was not contemplated when there was committed to the Commission the problem of securing for less than $1,000,000 many properties claimed by their owners to be worth in the aggregate twice that sum. This Commission has since 1912 been seriously hampered by this deficiency in funds available for taking property, and the Legislature has on three different occasions recognized the imperative need of the situation. It voted in 1912 to appropriate for this purpose $100,000. That bill was vetoed by Governor Dix on the ground as he stated that the money was not then needed, although it was his well-known and strong conviction, expressed in a letter to this Commission, that it was both wise and necessary to vote this sum. Again in 1913 the sum of $100,000 was voted by the Legislature for this purpose but was vetoed by Governor Sulzer with the expectation, as he afterward explained, of approving it at the extra session in a deficiency bill. He appended the following language to his veto:

> "This $100,000 appropriation is now disallowed as it was disallowed last year, because the Board of Claims has not yet been able to try the cases and it does not seem probable that they will reach a decision during the current year. It is understood that when the Board of Claims shall reach a

judgment or decision as to the price to be paid for these properties, the Legislature will, I believe, appropriate the funds to provide the amount of interest and expenses incurred by reason of the delay in trying these cases.

"Therefore, it does not seem to be necessary to appropriate the money this year.

"I have already signed a reappropriation of over $450,000 for the purposes of adjustment and payment of claims for lands and property appropriated by the State at Saratoga Springs, which seems to be more than is likely to be necessary for such agreement on compensation as the Commission is likely to reach this year.

"For the reasons stated above, I disapprove the item of $100,000 contained in section 2 of the bill, while approving the other portion of the bill.

"(Signed) William Sulzer."

The Legislature of 1914 cut the amount of the bill for a special appropriation to $50,000 which sum was voted by the Assembly and the Senate, but the bill was vetoed by Governor Glynn because of his general policy of economy and because he thought that the cash was not then needed and that the appropriation could be safely delayed. Governor Glynn expressed himself then, and later during the campaign, as heartily in favor of providing all the money that was needed for the proper development of Saratoga Springs.

The Commissioners, therefore, most respectfully urge the immediate passage of a special emergency appropriation for this purpose. They are glad to say that it will suffice to appropriate for this need, instead of cash from the General Fund, the $100,000 of bonds which will be available on March 1, 1915, when $95,000 of the issue made for this purpose in 1912 will mature. This will provide for the deficit in the Reservation land purchase fund without making an additional charge upon the General Fund of the State. They respectfully submit a bill drawn by the counsel to facilitate immediate action.

If this action is taken, the pressing necessity upon this Commission to provide amply and in good time for the season of 1915

can be cared for by the immediate acquisition of the building known as the Saratoga Baths under the option secured to the State. The Legislature can then take the necessary time to study the situation and become fully informed respecting the wisdom of the request made for the much larger sums required to enable the State to go forward properly with this great work. The Commissioners express the earnest request that all the members of the Legislature will arrange to make an early visit to the Springs to study the problem on the ground before taking action on any of those requests other than the matter of the $100,000 of bonds to make good the deficit which the Legislature sought heretofore to extinguish by several bills which were successively vetoed as stated.

GEORGE FOSTER PEABODY,
FRANK N. GODFREY,
BENJAMIN F. TRACY,
Commissioners.

Saratoga Springs, *January* 1, 1915.

Secretary's Financial Memorandum

The accounts for December and the full year, which have not yet been made up, will be included in detail later in this report. I give herewith in summary form the financial status, estimating the December accounts.

Chapter 239, Laws of 1913

Amount of original appropriation, $950,000 of bonds.

Balance, January 1, 1914		$399,353 28
Claims settled during 1914	$271,929 75	
Interest on same, and miscellaneous expenses incident thereto	49,144 87	
		321,074 62
Balance, January 1, 1915		$78,278 66
With which to meet unadjusted claims for land estimated to be fairly valued at	$170,000 00	
And interest accrued in excess of	8,278 66	
		178,278 66
Showing deficit in land purchase fund of over		$100,000 00

Chapter 252, Laws of 1914

Appropriation for general purposes, acquisition of land, interest on claims, etc		$235,000 00
Expended to December 1st, for repairs, improvements, new construction, including Lincoln Bath House and Park, and general maintenance, salaries, current expenses, etc	$70,000 00	
December estimated expenses, and construction and improvements contracted for but not vouchered	30,000 00	
		100,000 00
Balance		$135,000 00

This amount will be available to acquire the Saratoga Baths and make the necessary improvements and provide for the current expense necessities of 1915 *provided* the $100,000 deficit in land fund is *now* appropriated and, later on, further funds to take additional property known to be needed.

Original appropriation as voted in 1911 for purchase of property, from the sale of bonds.....		$950,000 00
Agreed value of property paid for to January 1, 1915.....	$765,889 75	
Estimated value of lands taken but not settled for (no case having been decided by Board of Claims) 21 claims; only two tried to January 1, 1915	170,000 00	
	$935,889 75	
Agreed and estimated value of all lands taken up to January 1, 1915.....		935,889 75
Balance of original fund not used for land purchase		$14,110 25
But against this, the State Comptroller has paid and charged against the fund interest and expenses on the lands paid for at agreed value to the amount of.....		105,831 59
This makes a deficit in the fund of.....		$91,721 34
There is accrued interest on the value of lands not yet paid for, in excess of.....		8,278 66
Showing a deficit in the land purchase fund because of interest accruals of.....		$100,000 00

This amount of $100,000 was voted by the Legislature to cover the deficit for interest in 1912 and again in 1913, and was vetoed in each year, because in the judgment of the respective Governors the cash would not be needed in those years to meet payments due.

It would seem imperative that there should be promptly appropriated the sum of $100,000 to meet the above deficit in the land purchase fund, inasmuch as claims against this fund will need to be paid early in 1915; and unless such approproation is made, the Commission will have no fund available for the acquisition of the building known as the Saratoga Baths.

For the five years and seven months of the Commission's existence, there has been appropriated for expenses of organization, salaries, insurance, repairs, improvements, destruction of useless structures and material, park development and expert investigations in Europe and America, also including new construction of considerable extent and in many places, the total sum of, from the general fund of the State.....	$137,500
In 1914, for the above and land purchase, the sum of (from the sale of bonds).....	235,000
Total.....	$372,500
Of this total, the expenditures for current purposes as above and construction, including the Lincoln Baths, for five years and seven months will be..	237,500
Leaving apparently available on January 1.....	$135,000
But the appropriation for purchase of land shows a deficit because of deductions for interest and expenses not calculated in taking land of.....	100,000
Leaving now available on January 1, only.....	$35,000

The appropriation of $100,000 of bonds now to make good the deficit of $100,000 will enable the Commission to immediately acquire the building known as the Saratoga Baths, and to pay for the necessary improvements to it, and to meet the current expenses and improvements for probably all of 1915.

January 6, 1915.

LOUIS W. NOLAND,
Secretary.

Report of the Superintending Director

To the Honorable, the Commissioners of the State Reservation at Saratoga Springs:

GENTLEMEN:— The prophetic vision, sagacity, and good judgment of the Legislature of 1909, as well as of his Excellency, Charles E. Hughes, Governor of the State of New York, have already been completely vindicated; for the operation of the Commission under the provisions of Chapter 569 of the laws of that year, as slightly amended from time to time, has already resulted in the transformation of Saratoga Springs.

The aboriginal Saratoga, the Saraghtogha or Saraghtoghie of the red man, and to us — at this distance in time — the romantic Saratoga, dates from a very remote period. Actual history and enticing legend provide a most interesting narrative if one chooses to construct it from available authorities. The appearance of the oldest Saratoga spring is shrouded in the obscurity of geologic ages; but it is fairly certain that a fire was kindled by some aborigines who camped by that spring, during the Second Crusade, if over the charcoal remains disclosed at a depth of sixteen feet the deposition of tufa was as rapidly made in those days by High Rock spring as in recent time by Geyser spring. It is indeed fascinating to think that while Conrad III., of Germany, and Louis VII., of France, were engaged in their unsuccessful attack on Damascus, a band of red men were making propitiatory offerings to the Manitou of High Rock spring about the year 1150. Brief mention should be made of the visit of the first white man, as far as we can conjecture, to the healing waters of Saratoga. From the *Jesuit Relations* we learn that a band of Mohawk Indians in 1643 brought with them to the Saratoga springs Father Isaac Jogues, who had been surprised and taken prisoner by a marauding band. Repairing to the "Medicine Waters of the Great Spirit" with their captive, they rested and secured refreshment and restoration to health and strength at the fountains whither they had been for ages accustomed to repair for relief from exhaustion and disease.

Saratoga of the olden time was a fashionable resort to which people came for pleasure of various kinds, incidental to which was the use of waters to correct errors of the digestive tract, from which so many votaries of fashion, devoted to " the pleasures of the table," suffer from time to time. People then drank these waters in order that they might be relieved of their discomforts and be able to sin again. It was fashionable to drink a certain water in the morning, another in the afternoon and sometimes a third in the evening, simply for the reason that everyone did so. The use of the medicinal waters then available was desultory and entirely governed by caprice and, in a large majority of instances, without any prescription or suggestion by the physician. Too much water was drunk by most people and too many varieties were drunk in one day. As far as we can learn at the present time the value of the carbonic acid gas was never recognized, except as it gave a pleasant fillip to the cathartic water as it was tossed down the throat of the guest. The bath, so arranged as to depend upon the content of the gas remaining in the water when it reached the tub, was entirely unknown. It was erroneously thought that the minerals dissolved in the bathing water were in some way absorbed by the skin and thus entered the system, and that they constituted the medicinal feature. It is small wonder, therefore, that when fickle fashion swung away from Saratoga, when the opening of new resorts attracted unstable and volatile minds, and when increased railroad facilities rendered accessible new and equally charming spots, the patronage of Saratoga decreased almost to the vanishing point.

Owing to the lack of the establishment of any system of treatment for any special class of diseases, and especially owing to the fact that the tremendous value of the waters for bathing, when properly controlled and installed, was not appreciated, there was no regular clientele coming back year after year to take treatment under the guidance of physicians here. In fact, Saratoga was not a health resort, though it possessed for a century the environment and necessary external features, with a vast treasure of mineral water in the underground reservoirs not only waiting to be developed, but leaping forth into the air, and inviting examination and use.

The action of your Commission, under the intelligent and fostering provision of the Legislature, has changed the scenes, so that the new Saratoga Springs is rapidly emerging from the chrysalis condition in which you found it and is expanding into an attractive resort for the thousands who are in search of health and pleasure.

There was no lack of analyses of waters in the olden time; for several of the physicians of preceding generations had made as accurate studies as the limited laboratory facilities of those days afforded. However, the new analyses made under your direction showed decided changes from the previous conditions of many of the springs, and now that accurate studies have been made of the use of various waters in various conditions of disease (close comparisons having been made with the well known mineral waters of foreign spas, hitherto, as it appears, little studied as to their resembling or identical features), Saratoga Springs is prepared to offer definite treatment for definite disorders.

In Wiesbaden, which lies 400 feet above the sea level, a few miles from the Rhone river, sheltered from the cold northern winds by spurs of the well fostered Taunus mountains, and frequented as a resort during the entire year, treatments are carried on to relieve gout, rheumatism, various joint disorders, neuralgia, sciatica, inflammatory exudates, heart disorders, certain nervous disorders and some diseases of the kidneys and bladder. These are all benefited by the bath treatment. The "Trink-Kur" is used in certain affections of the organs of respiration and of the digestive organs, as well as in gout and obesity. In Saratoga Springs all these disorders can be treated after the same methods, with the exception of affections of the respiratory organs. The waters at Wiesbaden are hot, but heat is merely a mechanical condition, which is as efficacious when artificially supplied above the surface of the earth as when due to combustion or pressure at a point far below the orifices of the Springs. The products of the Wiesbaden Springs are classed as sodium-chloride waters, taking their name from their principal ingredient, which exists in such large comparative quantities in the mineral waters of Saratoga.

At Baden–Baden, situated in the Oos Valley of the Black Forest, about 700 feet above sea level, there are about twenty thermal

springs used for bathing and drinking in the treatment of gout, rheumatism, catarrhal affections of the upper air passages, neuralgia and neuritis, and also inflammatory deposits, certain nervous conditions, certain skin diseases, as well as reduced vital energy and imperfect nutrition so often encountered in tardy convalescence after wasting diseases. Again, Saratoga Springs offers mineral waters exactly as useful, and destined to be as effective as the waters of Baden-Baden, though differing in mineral constitutents to a certain degree and lacking entirely the arsenic salt found in the principal springs of the Grand Duchy of Baden. Excellent paths ascend on various slopes through the valley, in order that the Terrain-Kur may be employed for the treatment of obesity and disorders of circulation exactly as the new paths and climbs throughout the ravines in Geyser Park of our State Reservation will be employed.

In Nauheim, the majority of patients now treated are suffering from heart and arterial disorders, although a different method of employment of the same waters was formerly used for digestive and joint disorders as well as certain nervous difficulties, before the application of the waters to the treatment of cardiac disorders was elaborated or proved. The waters of Nauheim owe their efficacy to the graduated temperature employed, the carbonic acid gas in them, the chloride salts in great abundance, and possibly to their radio-activity. The baths are given in increasing strength throughout the series, gas and mineral salts being added to the successive sets which comprise it. The German town is situated 448 feet above sea level, on the slopes of the Johannisberg, a spur of the Taunus mountains. The season for invalids extends from April 16 to October 15, but visitors not unfrequently encounter cold, rainy periods in July. Subsequently to their course of baths, patients are sent elsewhere for the "Nach Kur" (the "after treatment"), that they may enjoy advantages of climate and scene not obtainable in Nauheim. Nauheim enjoys a cool atmosphere mornings and evenings, from the neighboring mountains and has a porous, absorbent soil.

At Saratoga Springs facilities exist comparable with those at Nauheim. Saratoga Springs occupies a central position on a plateau about 25 miles square, averaging 300 feet above sea level

in the village and its neighborhood. The soil is sandy loam, clay, sand or glacial drift, and is in general very porous. There is a large proportion of sunny days and the sky has the blue of the open country. In 1912, 115 days were partially cloudy and 128 days were sunny throughout, making a total of 243 days out of 366 days on which the sun shone. In 1913, 101 days were partially cloudy and 133 days were sunny throughout, making a total of 234 days out of 365 days on which the sun shone. The air is unusually fresh, dry and tonic, owing to the large number of trees and the fact that the air comes to us from the boundary hills — the Kayaderosseras, foot hills of the Adirondacks, and the Palmertown range of the same mountains, together with the Green Mountains of Vermont — which furnish breezes from either side and from the North. Thus one at Saratoga secures the advantages of a mountain climate without enduring the rarification of the atmosphere of a high elevation, a most favorable condition for cardio-vascular sufferers. The autumn is a beautiful season in Saratoga Springs, with sunny days and cool nights, the air being tonic and bracing almost daily. There is no necessity for sending patients elsewhere for the after treatment, since no undermining or devitalizing agencies interfere with our climatic conditions. They remain here at the close of their course of baths, some taking a course of resisted movements, as devised by Beneke and improved by the late August Schott; some taking electrical treatment; some taking graduated and increased walking exercise, already mentioned as the "Terrain Kur".

In Kissingen, known as a saline since the year 824, and as a health resort since 1544, situated at the altitude of about 605 feet above the sea level, in the kingdom of Bavaria, on the southeastern slope of the Rhone Mountain, in the charming valley of the Saale river, the season lasts from April 15 to October 15; however, baths are given from the first of April to the end of October. This resort attracts about 34,000 patients annually, beside 14,000 other travelers, as estimated. In this resort are treated catarrhal affections of the digestive tract and related disorders including disorders of the liver, also affections of the heart and blood vessels, catarrhal affections of the respiratory organs, residues of inflammation, anaemia, gout, diabetes, obesity, and

certain nervous disorders, as well as selected skin diseases and affections of the kidneys. We learn from Dr. Paul Haertl, the accomplished chemist and general scientist holding an official position at Bad Kissingen, that the waters of Saratoga Springs are exactly adapted to the treatment of all the disorders named.

Marienbad is situated at a point 2,200 feet above sea level in a valley in the northwestern part of Bohemia, opening toward the south and entirely surrounded by dense pine forests. The principal groups of its springs are known as alkaline-saline; ferruginous; mineral-alkaline, "containing larger proportions of calcium and magnesia carbonates than the others"; and a single iron spring, Marienquelle, described as "poor in solids, but extremely rich in carbonic acid, and so an ideal means for natural carbonic acid baths". Marienbad also possesses special bog-earth, or moor-earth, which is used for giving its celebrated mud baths. The list of diseases favorably treated at Marienbad compares very closely with those that may be treated with the equally valuable waters of Saratoga Springs. Reference will be made later in this report to the facilities we possess for giving iron-moor baths with unusually valuable earth. (Page 33.)

Ems, situated in the Province of Hesse-Nassau, partly in the valley of the river Lahn and partly upon the lofty spur of the neighboring mountain, has been known as a watering place since the eleventh century. Its season lasts from May 1 to October 1. The maladies principally treated at Bad Ems are catarrhal affections of the respiratory organs and passages, disorders of the digestive tract and the results of inflammatory processes, as well as certain forms of kidney disorders and also joint disorders. Ems boasts several hot sodium chloride waters, and one cold iron spring, which the authorities in that town describe as "a weak acidulated chalybeate water".

The mineral waters of Saratoga provide agencies which will accomplish the same results as the waters of Ems, and far surpass Ems in respect to iron springs. At Ems a vacuum evaporation plant is in operation which produces a large quantity of soluble salts, extracted from the mineral waters and compressed into pastilles, for home use, after re-dissolving, for catarrhal difficulties of the respiratory organs and the digestive tract. Experi-

ments are now being made in our laboratory with the solid constituents obtained by evaporation of the mineral water, with a view of possibly producing similar pastilles.

In Franzensbad, Austria, 1,600 feet above sea level, the most celebrated mud bath in the world is maintained. Marienbad compares her moor-earth with that of Franzensbad as a standard; as stated later in this report, the available moor-earth of Saratoga Springs far surpasses that at either of these foreign localities.

In Homburg in the Taunus Mountains, there are six cold carbonic acid sodium chloride springs, and two iron springs. To avoid the weariness of a repetition of a list of diseases, it may be said that the Saratoga Springs waters are fully as efficacious as those of Bad Homburg, and it may be added that, since the percentage of free carbonic acid gas in our waters far exceeds that in the waters of Homburg, ours are destined to be fully as successful. Homburg provides mud baths given with a clay impregnated with iron, as well as the mineral water baths, and baths containing extract of pine needles.

In Karlsbad, Austria, the diseases treated are largely those of the digestive tract, diabetes, kidney disorders, and joint affections. This is the most largely frequented Spa in Europe according to official figures, though it has been reported that the number and disturbing features of many of their entertainments and diversions have resulted in a request by the physicians practicing in the resort that the authorities should control these diversions so that the drifting of patients away to other Spas may be checked. The system of baths at Karlsbad is elaborate but not all the waters contain sufficient gas for the ordinary carbonic acid gas bath. Therefore, gas is collected as it escapes from the Sprudel and is condensed and liquefied and then injected in the tubs in which the mineral waters baths are given.

Saratoga waters will fulfill the same indications as those of Karlsbad, although ours are much less powerful taken in the same dosage, and although the laxative ingredients of Saratoga spring waters are less drastic than those of Karlsbad. Moor-baths constitute a great feature at Karlsbad and many patients testify as to their efficacy.

In Vichy, patients to the number of over 118,000 a year are

treated for disorders of digestion, affections of the liver, of the kidney, of the bladder, of the joints, rheumatism in general, certain skin affections, diabetes, and anaemia. The bath establishments are very large and very luxurious, and thousands of people repair to this resort for a course of treatment annually.

I am convinced the maladies treated successfully at Vichy may be treated successfully here, by the studious use of various Saratoga spring waters. Dr. Simon Baruch, who in 1913 visited the establishment of Vichy, among many others in order to report to your Commission, was impressed with the resemblance of Saratoga Hathorn Spring No. 2 in its flavor and efficacy to the Grande Grille of Vichy. Bearing in mind our possession of the Geyser and Minnonebe waters, both with predominating alkalinity, a system of treatment fairly comparable with that at Vichy is perfectly possible.

Thus there lies before us just opened a vista of future, if not immediate, usefulness to suffering mankind coming to us from not only our own land, but also the countries of South America and Europe. It is the experience of every foreign spa concerning which we can get accurate knowledge of financial returns, that the Governmental control of springs for medical purposes is very lucrative, and that the income from these sources is constant and increasing. The increase in the number of patients visiting such a resort may be studied in the case of Nauheim for instance, where for many years special care was taken to refuse patients who could not be benefited by the treatment offered at this spa, as a result of which practice confidence was augumented and patronage was considerably increased directly, until the number of patients taking treatment at that spa in 1912 was 35,000, of whom 1,600 came from America.

Not only are the resources of Saratoga now made available, through the action of the Legislature and Governor already mentioned, but the field of usefulness is rapidly widening during these years of close competition and strenuous life. The numbers of men and women who should be in the prime of life, but who suffer a great lowering in their efficiency and their capacity for enjoyment because of the impairment of vital organs, are increasing at an alarming rate, especially in our great cities. Recently " wel-

fare work" has been instituted among thousands of employees of our large manufacturing establishments, in order that the ordinary facts concerning housing, food, work, recreation, rest, education, etc., may be taught to a certain degree, to the end that the employees may preserve their efficiency longer, and may be of real value to their employers throughout the entire part of their life, which in most cases is devoted to labor. Nor is the impairment of functions or disease of vital organs largely confined to the artisan or mechanic, or the general employee of the factory. Fully as many instances are encountered in thousands whose work lies largely in fields of mental activity, such as clerks and officers in banks. Recent examinations show that a very large percentage, in one bank 100 per cent., of the clerks and officers show chronic disease of such a character as greatly to limit their efficiency, and of such a gravity as to be beyond cure. Very many of these prospective invalids could have been prevented from reaching a point of incurability, had they been treated properly and early, and many could have been easily cured had the first premonitory symptoms been recognized and regarded.

The "Cures" to be offered at Saratoga Springs are of such a character and variety as to meet most of the difficulties existing in those suffering from commencing invalidism, to which allusion has been made, either as palliatives or partial restoratives, operating so as to lengthen the life and increase the comfort of the persons permanently impaired, or to assist nature in effecting an absolute cure.

The fact that such a possibility is now opened for suffering humanity should be a cause of great congratulation for the Legislature and the Governor, who made it possible for a conscientious, devoted and intelligent Commission to accomplish the results thus far attained. To the Legislators and Executive, therefore, must be given a share of the credit which is hereafter in this report ascribed to the members of your honorable Board.

A review of the progress and achievements of the State Reservation at Saratoga Springs during the past year inevitably leads to an appreciation of the wise methods adopted throughout the early formative period, during which conditions were studied; rights, titles and interests were carefully weighed; and plans were

adopted and elaborated. Had it not been for the wise counsel and deliberate advance that contributed to lay broad foundations and to commence great developments during the four years preceding 1914, no such results could have been accomplished as those of the annual period now drawing to a close. Perhaps the advances of the closing year are more patent and more convincing than the accomplishments of any earlier year; if so, these advances were possible only because of a previous broad comprehension of needs and possibilities, a calm and yet forceful handling of many problems, an artistic and imaginative treatment of material, and an actual and increasing knowledge of the great agencies of health existing at Saratoga Springs for centuries, awaiting sagacious and practical control and employment by such an administration as that of your Board.

Your duty under the statute which created your Commission, as accepted by your body, is to restore, develop and utilize the healing waters of the mineral springs. Developing such a Health Resort as is now being created by the Reservation Commission and the village of Saratoga Springs is, of course, the end and aim of the undertaking, which in a few months will provide moderate and initial opportunity for partial or complete restoration to health of thousands who look to Saratoga for relief from disease and recuperation of efficiency, from all over this Continent. The great fatigue and expense of an ocean voyage, the doubtful experiment of encountering an untried climate, and the puzzling and discouraging experience of dwelling during a protracted course of treatment among people few of whom speak the English language, all these difficulties are removed from the path of the invalid who comes to Saratoga Springs from any part of our own country to enjoy the provisions made here by the State of New York.

The experience of English, Austrian, French and German chemists, engineers and physicians has aided in our guidance; for through your wise action last year in securing the results of Prof. Baruch's observations in foreign Spas; of Dr. Haertl's teaching and consultation during his brief residence here, on leave of absence from Bad Kissingen; and of the previous wide experience of our own Consulting Engineer, Prof. Anthony,

added to his acquisition, during a study of eight European Spas, of special knowledge of the mechanical devices and installations used in handling mineral waters containing carbonic acid gas, New York State launches this enterprise in Saratoga Springs with a tremendous advantage. This advantage is enlarged by natural conditions. A great and increasing supply of mineral water, easily obtained and controlled; a favorable climate as determined by soil, relative absence of humidity, existence of sufficient groves of beautiful trees, and proximity of mountain ranges; a moderate elevation above sea level; and a situation at a point of easy access from almost all directions by millions of people combine to render this spot peculiarly suitable for the creation of a health resort.

During the past year observations of the movement of the mineral waters have been prosecuted, and the changing water levels in wells and bores have been accurately charted, adding to the graphs commenced when your Commission began to acquire the properties and mineral rights, and forming a mass of unique information of much scientific and practical value. Comparative studies are enlarging our knowledge of the "upper ground waters" as well as of the underground reservoirs of mineral water, so that we can come nearer to answering the questions as to the origin of the mineral waters, the direction of their flow, and the steps necessary to protect them by establishing zones of safety, as well as their probable future conditions.

The Chemical Laboratory established and equipped during the year has been of prime importance. A separate report is made by our learned and industrious chemist, well known in New York State as a water analyst of great ability, Mr. Herbert Ant. Repeated and regular analyses show progressive increase in the mineral constituents of many of the waters, notably the celebrated Hathorn No. 1, which has increased by 10 per cent. during the year, and the Gyantwaka (Champion No. 1), which has increased 300 per cent. during a few months. Bacteriological examinations are also made in order that contamination, if it occur, may be promptly ascertained and in future prevented.

Studies of the mineral water as delivered in the tubs in our High Rock (formerly Magnetic) Bath House, as well as in the

Saratoga Baths, have been very instructive. It has been of decided advantage to the Commission to have the Saratoga Baths (still owned by a private individual) leased and managed by as competent and intelligent a bathmaster and masseur as Mr. Oscar R. Stenstrom. The owner permitted the installation of apparatus for neuro-vascular treatment, a valuable agency for use in anaemia, insomnia, neurasthenia and obesity. In this house the water of the Hathorn Spring No. 1 is used, conducted to the existing attic tank in such a way as to preserve the gas content in amply sufficient amount for administering the Saraghtoghie Bath (Nauheim Bath) properly, with the provision of Rest Rooms, the latter impossible in the High Rock Bath House. Observations of value upon temperature, specific gravity and reaction of the bath waters in both bath houses have been made.

Besides brine baths, carbon dioxide (Nauheim) baths, neuro-vascular training, Turkish and Russian baths, the State will be able to give Iron-Moor Baths, as at some of the foreign spas, specially Marienbad. The moor soil that will be used for this purpose is very abundant, having been permeated for many years with a rich iron mineral water escaping from the Karista (Iron) Spring. The vegetable substance in this soil is decomposed and carbonized and largely dissolved in the mineral moor. Hence, it will need very little treatment before being utilized in giving the moor bath. Marienbad claims iron mineral moor containing "a larger percentage of iron than any moor earth so far analyzed, even more than the Franzensbad moor earth". The Marienbad soil contains 2.04 per cent. of ferrous oxide, while the soil proposed to be used at Saratoga Springs contains 3.72 per cent. of the same oxide of iron, thus offering a still more valuable material than the best of the kind known in Europe. The iron-moor baths are recommended for various nervous disorders caused by anaemia, partial paralysis caused by exudation within the sheaths of nerves, as well as hysterical paralysis, rheumatism, gout, certain circulatory disorders, and injuries such as sprains, and also the results of dislocations and fractures.

Hydrotherapy, as practiced at Saratoga Springs, includes the use of the baths already mentioned, as well as brine baths, douches, colon irrigations, packs, fomentations, sprays, etc. The

term properly includes Balneology (medical baths), while Crounotherapy denotes the use of mineral waters for drink-cures. The practice of hydrotherapy should not be a specialty, any more than should the prescription of tonics, or of digestants. Hydrotherapy is simply a part of the general practice of medicine, for its agencies may often be used to great advantage in place of vegetable or mineral drugs, and with better results; for, by means of these agencies, recuperation and restoration of vital processes is often secured in cases wherein drugs produce but a temporary condition, under cover of which nature is expected to assert herself. But its principles and practice should be well understood by those who prescribe its measures.

Other varieties of treatment will be added when funds are available for the erection of the State bath house; such as physical exercises, including the Zander and Swedish, as well as a certain amount of gymnastic work.

It will be unnecessary to provide for X-ray examinations or treatments, since this department of medicine is fully covered by the provisions made at the local Saratoga Hospital, where Dr. Earl H. King, of Saratoga Springs, has installed a full equipment and has proved himself to be a scientific and successful roentgenologist.

Electrical treatment should be provided in special rooms in the bath house to be erected by the State. A full equipment, including Galvanic, Faradaic, Static, High Frequency current with chairs for auto-condensation, and Sinusoidal current, also the Violet Ray and the Lecodescent Light should be installed with the necessary appliances for use.

There remains but one more adjunct to other treatments to mention, beside diet, which must be left to the individual physician. This remaining agency is exercise. In the State parks, Lincoln and Geyser, paths have been laid out providing for definite exercise by walking a measured distance upon a level, upon a slight incline, or upon such decided inclines as to constitute climbing. These paths are thus designed and developed in order to provide what are called the "Oertel hill-climbing exercises", so valuable to individuals who are recuperating during heart disease, forming part of what is known by the Germans as the Terrain

Kur. The aesthetic features of the Reservation property as developed through the artistic sense of your Commission provide much that is essential, though often unnoticed by the average individual. The most speedy results are obtained amid an environment providing rest and peace, together with features that are attractive to the eye and sufficiently varied to avoid being tiresome. The Oertel walking exercises could be carried out upon slopes arranged within the walls of a gymnasium which might be well ventilated and free from dust; but the tedium and weariness of repeating exercises under these conditions would render them far less beneficial and would defeat their aim in the case of the ordinary individual. "The soft influences of nature," the hillsides dotted with ferns, the brooks with ripples and eddies, the shallows planted with sarracenia, the occasional glen filled with meadow orchids, the shimmering hemlocks and shadowing beeches and birches over all, combine to render the exercise a delight; so that the patient is not conscious of the distance he has gone or of any fatigue in the process, beyond the comfortable feeling that accompanies equalized circulation and warm and relaxed skin surface. In certain foreign spas, so much attention is paid to the impression upon the weary, weak and occasionally irritable patient that trees have been pollarded, with the idea that to many people tall trees are disturbing and annoying. Hence vistas have been opened up through the natural low shrubbery and forestry in the woods of the Geyser park, trails and paths have been constructed, preserving the natural beauties and making nooks and dells available and accessible, while frequent rest places will be provided here and there for the complete comfort of those who come to us in search of health and pleasure.

The Pine Promenade, stretching a mile away in a straight line, diagonally bisecting Lincoln Park and nearly tying up the village of Saratoga Springs with the hamlet of The Geysers, forms a vital part of the walking exercise scheme, and will later prove a most notable feature of Saratoga Springs the whole country over. The provision for wheeled chairs upon one of the side paths of this promenade will be of great value and interest to patients who, coming from the village on the trolley for this short distance, will be transferred from the trolley station in the edge of a beautiful

pine grove to the door of the Lincoln Bath House with the minimum of fatigue or disturbance.

Nothing that your Commission has accomplished will be of more actual value to invalids this year than the adaptation of the old Lincoln Spring House, by means of which it has become the Lincoln Bath House, now being equipped with the appliances necessary for giving about 325 treatments during the usual bathing hours of each day, including the brine, the carbonic-oxide (Nauheim) and the plain mineral baths, as well as neuro-vascular training, colon irrigations and the Plombière treatment (employing water from Hathorn No. 2 or No. 3 springs), salt rubs, oil rubs, packs, fomentations, massage, etc. This provision will be made available in May, 1915, for the care of patients who otherwise would seek treatment in foreign spas, to which many of them have been accustomed to repair annually, and to which many have been unable to go for treatment because of the distance and expense, as well as the fatigue incident to long travel — especially ocean travel — in the case of patients suffering with heart or arterial disorder.

The enumeration of the mineral waters of Saratoga Springs used for "drink-cures" remains as stated in my last annual report. The saline-laxatives, Hathorn No. 1, Hathorn No. 2, Coesa, and Orenda (formerly Adams) are bottled for the trade, and are also served at the Hathorn Spring Building, as are in addition the alkaline-saline waters with predominating alkalinity, Geyser and Minnonebe, both used widely as table waters. The Karista (formerly Flat Well No. 2) and the Columbian are the chief alkaline-ferruginous or chalybeate springs, both available at their sources. It has been necessary to close the Old Red and New Red Springs because of contamination from the soil in their locality. The Old Red was made available by means of a square wooden trough carried down at the point where the spring reached the surface in 1784. The New Red, recently deepened by drilling into the rock a short distance, has always been obtainable only from the stratum of earth lying above the rock, and the new bore drilled into the rock yields no water. The layer of clay, which formerly protected the mineral waters, that flow in the gravel and shale of the lower strata, from the upper ground waters and from general percolation, became pervious at this point in many places,

and thus the local underground reservoir is contaminated. The Magnetic Spring, formerly an iron spring of large repute, and so named because its iron outer casing had become magnetized, ceased to flow over a year ago, and has, therefore, been filled up. The water which formerly supplied it has undoubtedly found its way by means of new solution channels into the general basin from which the Emperor and Peerless flow a few feet away.

Excellent Indian names have been used to supplant the former crude appellations by which many of the springs were known; for instance, Zalama ("Sweetheart") and Alnoba ("Warrior"), situated directly opposite each other in a small picturesque ravine, having been assigned to Clark No. 1, and Clark No. 2 springs respectively. Pump Well No. 4 has been named Tallulah ("Leaping Water"); while Flatwell No. 2, the great iron spring, is now known as Karista ("Iron"). The old Pandora, which flows noisily in a large bowl in Diondaroga ("The Vale of Springs"), is now termed Awassa ("Where the Bear Drinks"); and Champion No. 1, which spouts continually in Diondaroga, has been named Gyantwaka.

While all of our springs are radio-active, we have not laid much stress upon this feature, for the reason that thus far the use of radium emanation is still in the experimental stage. However, it is a settled fact that radio-active waters are of decided benefit both internally and as bathing waters in cases of gout, rheumatism, bone and joint disorders, as well as neuritis, including sciatica, and in neuralgia. It is claimed that radio-active water is of extreme value in anaemia.

Directly from this office and with the help of public-spirited citizens, many thousand pamphlets providing information for patients and the public, and others providing special information for physicians, have been circulated to the profession and to many laymen in different parts of the country. The distribution of 25,000 pamphlets to physicians in twenty-nine states is now almost completed. This advertising is necessary for we have encountered many of the medical profession who are entirely uninformed concerning the properties and value of our waters. Two of our pamphlets of information have been translated into and printed in German, Spanish and Portuguese, the two latter especially for use in Cuba and South American countries.

Addresses have been delivered before certain medical societies, and more are projected at various localities including Philadelphia, where arrangements are being made for a presentation of the facilities of Saratoga Springs before the great Philadelphia County Medical Society in January, 1915. This publicity is an important part of our work, for the medical profession needs accurate and complete information concerning the provision made by New York State to meet the necessities of patients formerly treated in Europe, as has been stated.

As suggested to your Commission a year ago, though not then imperative, it seems desirable to establish centers of information as well as of distribution of the drinking waters in New York and Philadelphia at this time, that the success of the State's enterprise may be more immediate.

Advertising in the daily papers has been pursued to a very moderate extent, and special advertisements will also run in a few important medical journals. This step has been necessary in order that the Commission might more easily learn the value of the bottling franchise, and therefore, be better prepared to execute a long lease to some responsible individual or firm that will properly exploit the drinking waters.

But the principal facts to be brought to the minds of patients near and distant are the ones already stated, namely, the great remedial value of our bath waters charged with carbonic acid gas and the easy accessibility of Saratoga Springs.

The fact that, when properly equipped, the State will be able to reap a large return and enjoy a constant income amounting to a very handsome percentage of the outlay here, is becoming more prominent, not only through the study of the large incomes enjoyed by foreign spas, where initial and repeated large appropriations have been made for development and equipment, but also through the study of the new statistics provided by those who are investigating the average loss of efficiency in all our large cities, due to many chronic diseases that early treatment would have prevented or cured, had the unfortunate victims taken advantage of such opportunities as the State of New York is now providing at Saratoga Springs. It is a fact that if the hard working, over-fed, under-slept business man would submit himself to a careful medical examination and possibly treatment once

every half year, early stages of serious diseases would be detected, and in a large number of instances serious development of disease could be prevented, and the life and efficiency of the individual could be prolonged for many comfortable years.

Respectfully submitted,

ALBERT WARREN FERRIS,

Superintending Director.

Saratoga Springs, N. Y.
January 1, 1915.

Report of the Consulting Engineer for 1914

SARATOGA SPRINGS, N. Y., *December* 18, 1914.

To the Honorable, the Commissioners of the State Reservation at Saratoga Springs:

GENTLEMEN: On the 24th of December, 1913, you commissioned me to go abroad and investigate several European Spas. In compliance with these orders, I visited Vichy, Kissingen, Brückenau, Saline, Wiesbaden, Nauheim, Homburg, Harrogate and Bath. At each Spa I made a comprehensive study of the mechanical equipment, pipe systems, buildings and parks; and I submitted a detailed report covering all physical and engineering features of importance.

Before going to Europe I had, as Consulting Engineer to the Commission, made a study of the conditions at Saratoga Springs. My study abroad enabled me to observe, on my return, the absence of such scientific consideration of the problem in the past practice at Saratoga Springs as is now utilized in similar problems abroad. The previous experience which I have had in sinking wells and developing water supplies in our own country gave me definite points of view from which to make comparisons. I found this comparative study of the utmost importance in discussing the problems with manufacturers and engineers, and in consequence we have been able to modify designs used abroad, even the most modern ones, so that the State of New York will make some new departures in details of practice that will give it an advantage over the most successful resorts.

After my return from Europe, in addition to the performance of my duties as professor at Union College, I continued to make a fuller study of the conditions here in the light of the knowledge I had acquired abroad, and I have had the superintendence of construction work as well.

The first work undertaken under my supervision was the construction of the High Rock pit. This development was something

entirely new in this country. I have followed the practice which has proven so successful at the German Spas. The High Rock spring was formerly equipped with a six-inch steel casing extending to the rock, and a six-inch bore extended from the surface of the rock to the bottom of the well. In carrying out the new construction, the steel casing was removed and a pit 18 feet deep and 6 feet in diameter was constructed at the mouth of the bore. The pit was made of concrete and is thoroughly waterproofed, so that the seepage of groundwater is impossible. Extending from the bottom of the pit to the rock is a 6½-inch wooden pipe. The wooden pipe is surrounded by a 12-inch cast iron pipe, the opening between the wooden and the iron pipes being filled with cement grout. This arrangement insures the constant supply of a large quantity of water, always highly carbonated, and a permanent source of supply for the High Rock Bath House. Much difficulty was experienced in the construction of the pit, owing to the fact that the pit was always full of large quantities of CO_2 gas. The bottom of the pit is provided with special fittings for the regulation of the quantity and height of flow of mineral water, so that the spring is now under absolute control. Before this construction may be considered complete, the upper portion of the pit should be properly tapped, in order that a continuous flow may be maintained from the spring, which at present is sealed off and not flowing. This drain should be constructed in the early spring.

Red Springs

Bacteriological examinations made at various intervals during the past year by the State Department of Health showed pollution in the Old Red and New Red springs. It became necessary to make a complete examination of these springs and decide definitely whether or not sanitary conditions were such that they could be safely operated, because the water was in great demand, being used continuously by citizens residing in the vicinity of the springs. A drilling machine was moved to the site and a bore made in the centre of each spring. Samples of water were taken every five feet and complete analyses made. The results of the investigation showed that the mineral water came in through the clay at a depth of fourteen feet from the surface. Any casing

below this point shut out the supply of mineral water, and at no greater depth than fourteen feet would the springs flow.

It is dangerous to drink water from this spring only fourteen feet deep, on account of the proximity of the underground village brook and the sewer. Therefore these springs were not retubed and are not now being used for drinking purposes. Undoubtedly they should be permanently closed, and I have so recommended.

Closing Bores

As a measure of conservation it was desirable to prevent the escape of gas from the two bores known as the Hathorn North and the Hathorn South. In case there should be a demand for this water at some future date, a scheme was devised whereby these springs could be hermetically sealed, but leaving the water always available by the simple procedure of removing a hexagonal nut with a wrench. This system has proved so efficient that the same method has been used in closing the United States and Pavilion springs.

Retubing Wells

The next radical departure from the methods previously followed at Saratoga Springs was our action in commencing to replace all iron casings and tubings in the various wells with materials recommended by foreign Spas. At Kissingen and Brückenau I found all wells tubed and cased with phosphor-bronze, an alloy of tin and copper only, while in Nauheim, Wiesbaden, Homburg and Vichy pure copper was used. It was found to be impossible to secure phosphor-bronze of the proper amalgam in this country, and after a careful study we decided to tube the Saratoga wells with pure copper, at a smaller expense than would be entailed by the use of the foreign phosphor-bronze, although copper is a very costly material.

The result to date is that the tubing of copper was placed in the Hathorn No. 1, Minnonebe, Geyser and Orenda springs, and an order has been placed for sufficient copper to tube the Hathorn No. 2 and Coesa springs. In all of this copper work, special fittings have been designed to reduce the friction to a minimum, thus diminishing the loss of gas.

As stated, copper makes an expensive pipe, and in some of our longer pipe lines the use of copper would have made the cost of development almost prohibitive. It was deemed advisable to find some suitable substitute to be used wherever a substitute was possible. The result of this research is recorded later in this report.

Equipment

The former absence of unified ownership of the wells in this village naturally resulted in an absence of uniformity in the bores and of standard construction methods. My observations abroad enabled me to determine that it was desirable to change the construction at certain of the wells, and to do this additional equipment was necessary.

A Keystone drilling machine, capable of drilling an 8-inch hole one thousand feet through solid rock, was purchased, and also a portable pumping plant, consisting of a suction pump and a Cook gasoline engine, mounted on wheels. This last piece of apparatus has been in almost constant use for the past six months. All necessary apparatus has been added to the above equipment, and the engineering staff is now able to handle all field construction and research work in a thorough and workmanlike manner.

High Rock Bath House

The next immediate problem was the improvement of the facilities for giving baths at the High Rock Bath House, known for many years as the "Magnetic Bath House," in order that the baths given there might be more nearly up to the modern standard, in spite of the limitations of the plant. It proved necessary to change some of the equipment, and also to connect with the High Rock pit for additional water supply. This bath house had used water from the Emperor and Peerless springs, which is naturally high in CO_2 gas; but under the methods used in the bath house prior to January 1, 1914, very little gas actually reached the tubs. For this reason the baths were not efficient for certain treatments, such as the Nauheim system for heart troubles, in which a large percentage of free gas is necessary in the bath before the treatment has any value. A test of the water previously used for the baths showed only 4 per

cent. supersaturation, whereas 25 per cent. is absolutely necessary to make the baths efficient for the later Nauheim series.

Some apparatus like that used abroad was immediately installed. The plumbing was rearranged and a large pump and special apparatus for heating the water were designed and constructed. After this installation, the supersaturation of gas in the water rose 33 per cent., 8 per cent more than was necessary. It may be said with perfect safety that the baths given this year at the High Rock Bath House were superior in this respect to those at Nauheim and Homburg, and equal to those at Kissingen and Brückenau.

With the completion of the pit at the High Rock spring, additional changes can be made to increase the capacity at this bath house. The High Rock spring water will be used in the baths given next year, replacing the Emperor and Peerless waters. I believe that this change will show further increase in the gas content in the water, and that the mineral water used in the baths given under this arrangement will not be excelled at any spa in the world.

Saratoga Baths Establishment

With such favorable results shown at the High Rock Bath House, it was deemed desirable to deliver the State mineral water used at the Saratoga Baths in such a manner as to give greater efficiency to the baths at that establishment. The antiquated plumbing in this bath house made the problem a difficult one, but the changes made resulted in supplying water for these baths containing a higher percentage of CO_2 gas. It is now manifest, however, that in order properly to utilize this substantial and excellently located building, the plumbing and equipment should be thoroughly remodeled. As the State has recently secured an option from the owner to sell this bath house to the State at a moderate price, a study is being made of the most economical methods of bringing this very desirable building into efficient and permanent use. A moderate sum expended in repairs and changes should bring it up to date. I venture strongly to recommend that the Saratoga Baths be now purchased, remodeled and used for immediate additional facilities as a central bath house, for patients of moderate means, to meet a necessity which will continue when the projected new and elaborate State bath house is constructed.

Reclaiming Congress Spring No. 1

It is customary to associate Congress spring No. 1 with all the past glories of Saratoga Springs. When the village was at its height as a summer resort, Congress water had a worldwide reputation. The original water disappeared after the operation of the carbonic gas companies at Saratoga began, but inquiry for it continues still and work is now underway to recover it. To do this it is necessary to penetrate to a depth of 375 feet, through what we find to be layers of unusually hard and flinty sandstone and limestone, to strike the same vein that supplied the water to the original spring. The work of drilling a six-inch hole through these formations is progressing favorably at an average rate of ten feet per day, and at this rate the bore will be completed by the New Year. At present it has reached the depth of 245 feet.

The old Congress pavilion has been removed, and under your instructions a small ornamental building is being designed to surmount the spring. This will be made more like the original treatment, and in keeping with the beauties of the surrounding park.

Concentration of Mineral Water Bottling

To insure greater efficiency and economy, a system with new features has been worked out whereby the waters now being bottled under the direction of the Commission, in three different bottling works, can be bottled with a smaller force under one roof. The Geyser bottling works has been decided upon as the most available for this use. The Orenda spring, undoubtedly one of the best ever discovered at Saratoga, produces water very similar in contents to that of the old Congress spring, and has now been put on the market. A new pressure system was devised and installed, and the Orenda water now appears in the bottle naturally carbonated and entirely free from sediment. The scheme used is original, and although probably no similar device is in use in any other part of the world, it has proved entirely successful.

A similar plant is now being installed at the Coesa and Hathorn No. 2 springs, by means of which the waters from these springs will be carried through wooden pipe lines to the Geyser building, where they will be bottled, naturally carbonated. These mechanical appliances have been so designed and assembled that the water

may be carried great distances without any change in its natural condition.

A number of changes were found necessary in the Geyser building in order to increase the efficiency of the plant. A new boiler has been installed this year to furnish hot water for sterilizing the bottles and steam for the heating plant. In order to insure the use of natural gas for recarbonating, a gas container was constructed in the building, and it is now possible to supply all the natural gas needed for the extra carbonation of the Minnonebe and Geyser waters, which some regular customers demand. All iron pipe in the building has been replaced with copper and a glass storage tank has been ordered and will be set up in the very near future. New concrete floors have been placed in the two north rooms. It seems clear that the Commission can now rightfully enter the field of CO_2 gas supply, and I suggest that plans be prepared for conserving and utilizing the gas now going to waste, and put into operation at an early date.

Development of the Soft Sweet Spring

From the beginning of the study of the hydraulic problems of the Reservation it has been evident that a pure sweet spring water was most desirable; but so many details required attention that it was not until August that I was able, with the co-operation of the chemist, to make a full investigation of the resources in fresh water. A systematic survey has since been made of the many sweet water springs in Geyser Park. Samples were taken from fifteen different springs of still water and analyzed in our laboratory. The results were exceedingly favorable. Upon evaporation to dryness, all of the waters showed less total solids than the principal marketed pure still waters. The spring showing the smallest total of solids was found located near the Willow Gate of Geyser Park, in a very picturesque ravine, and it has been chosen for development.

After making personal inspection of the most improved plants, a bottling plant was designed and approved by the State Architect and is now being erected under your directions. This will be promptly equipped for the bottling of this water, which has been named "Saratoga Soft Sweet Spring Water." This bottling plant

is located on the bank of the ravine near the Willow Gate. The building will have a floor area of about nineteen hundred square feet, and it will be divided into five parts: a reception room, a bottling room, a sterilizing and washing room, a room containing shower baths and toilet, and an office. The boiler room will be placed adjacent to the main building, and will have a floor area of four hundred square feet.

The reception room is so designed that the public may view the bottling operations through plate glass partitions, and observe the sterilizing and filling of the bottles. The halls will be so arranged that the workmen first enter the shower baths, where street clothes will be discarded, and after the bath they will clothe themselves in white suits and white rubber boots before they enter the bottling room.

None of the equipment is over elaborate, but it has been so designed that complete sterilization and absolute hygienic conditions will exist, from the spring to the bottle. The spring itself will be carefully lined with polished white marble and surmounted by a plate glass dome, the dome being hermetically sealed to the marble to prevent any possible chance of pollution. The water will be taken from the spring to the bottling works by means of a silver plated pump, through block-tin-lined pipe to a glass storage tank. From the glass tank, in the building, the water will flow by gravity through glass pipe to the filling machine. Before being filled, the bottles will be washed in a soda solution, rinsed with clear water, subjected to live steam for eight minutes and then sprayed with a jet of boiling water. Arrangements will be provided for properly sterilizing the crowns to be used in sealing the bottles. All of these precautions have not so far as we know been taken in any other bottling plant. No detail has been too trivial for careful consideration, for the plant should and must be completely sanitary. The work is expected to be completed and the plant in operation by the first of March.

Lincoln Bath House

When the European war developed as an immediate problem the question of the available bathing facilities, a careful study of the Saratoga institution was made. It was found that, by the ex-

penditure of a moderate sum of money for improvements and changes in the Lincoln Spring building, it could be converted into a good bath house. This building is one of the structures taken by the State, and was originally used for the securing and marketing of CO_2 gas obtained from the spring waters. Designs were perfected for installing thirty-eight bathrooms and fifty-six dressing booths; two compartments being set aside for neuro-vascular training, two rooms devoted to massage and four rooms equipped for colon irrigation, ample rest rooms and a reception hall being provided and arrangements made to serve such medicinal waters of the Reservation as may be desirable. The contracts for the construction were prepared and are being carried out.

In the rearrangement of this building, very little expense has been incurred for ornamentation, the bulk of the effort and expense being devoted to the mechanical appliances, in order to give the establishment its maximum efficiency. It may be said that no spa abroad has given more attention to mechanical detail than will be given to the mechanical system and appliances to be used in this building. All of the most improved foreign apparatus has been installed, and it is believed that the foreign practice has been improved upon in several minor details. All power, storage and air compressors are installed in duplicate; 50 per cent. of the apparatus being driven by steam and 50 per cent. by electricity. The bath house power system has been divided into an electrical and steam unit, each complete in itself and capable of running the bath house if for any reason the other should fail.

An interesting and important feature has been added at small outlay, consisting of two outdoor swimming pools, surrounded by dense shubbery, a grass lawn and a sand court. The pools will be equipped with diving towers, spring boards, and an unique system of filtration, installed to insure pure water. A comprehensive system has been planned for Lincoln Park in connection with this bath house. Many of the roads and paths have already been constructed and several thousand trees planted in the park.

Development of a Fresh Water Supply

A great number of complaints were made during the year regarding the condition of the water furnished to the Reservation by the village water system. The water during August was indeed repulsive, owing to an odor and taste generated by algæ which thrive and develop under certain conditions in so many reservoirs. Arrangements were therefore made and designs perfected by the Engineer to connect the supply of fresh water, necessarily developed in Lincoln Park for use in the plant equipped there, with the park and Reservation buildings in the village.

This pure water on the Lincoln tract is soft in character, analyses made in our laboratory showing total solids of only 145 parts per million. This is an unusually good water and compares favorably with the waters placed on the market by drinking water companies. The State has a very large supply of this water, and the plant has been designed to deliver 30,000 gallons per day. At a very small expense the capacity of this plant can be increased to 100,000 gallons per day when the projected new and elaborate State bath house is constructed and a consequently larger demand is made upon the water supply system.

The plant as designed is a hydro-pneumatic system, the pressure in the system being secured with a Clayton air compressor. The water to be used will be forced into a hermetically sealed tank by means of two large Worthington pumps operated by steam, capable of delivering 200 gallons per minute each. This water will be connected with the Reservation buildings in the village by 9,000 feet of 4-inch wooden pipe. The pipe used in this installation effects a great saving over the iron pipe used for work of this kind, for the following reasons:

(1) Iron pipe costs 50 to 59 cents per foot. Wood pipe costs 33 cents per foot.

(2) This special wood pipe is practically indestructible when placed in the ground and kept full of water. Iron pipe laid in the vicinity of the Lincoln building where the ground is saturated with mineral water, cannot be kept in repair over fourteen months, and cases have occurred where iron pipe has been entirely destroyed in less than that time.

(3) The cost of laying machine-made wood pipe is far less

than that of any other class of pipe, owing to the fact that no joints have to be made up.

(4) The cost of transporting wood pipe over rough country or muddy roads is less because of the lightness of the pipe, and for the same reason it can be unloaded from the cars without the use of a derrick and by a small gang of men.

(5) Wood pipe, being a nonconductor of heat and cold, can be laid two feet underground instead of five feet without fear of damage by freezing of the water in it, thus saving a great deal in the cost of trenching.

(6) As the value of a pipe line investment is proportional to its delivery capacity, wood pipe of necessity has to be chosen, because it has been found that the roughness of the inside of wood pipe varies from .0096 to .0110 while for iron pipe the roughness varies from .0115 to .02.

This wood pipe, used under the same conditions to which we subject these pipe lines, has, we find, proved satisfactory after a period of twenty-seven years, without disintegration or other faults occurring in the line, and without giving a taste to the water.

Rearrangement of the Hathorn Building for Use as a Drink Hall

Since the Commission at present has neither a satisfactory site for a new drink hall, nor sufficient funds with which to erect such a structure, it was found necessary to remodel the interior of the Hathorn building so that it might, as far as possible, meet the immediately pressing demands for a more modern and conveniently furnished drink hall. The building has been painted inside and out, in white trimmed with green, and several features of interest have been added to the building to make it suggest in some respects the well-equipped drink halls abroad. The principal new feature will be a large multiple drinking fountain, constructed of burnished copper. It is so designed that a number of patients can individually and simultaneously fill their glasses with different mineral waters. The fountain is 24 feet in diameter, and will have a rack effect constructed of copper pipe, standing 4 feet high and capable of serving 24 patients per minute.

A system of expansion tanks and pressure regulators will be installed so that the water will be served naturally highly carbonated.

In addition to the multiple drinking fountain a warming table will be placed in the drink hall, so that the mineral waters may be served warm upon the physician's prescription. A more suitable fountain has been designed to replace the rather primitive one now in use at the Hathorn No. 1 spring. An ornamental partition has been designed and is now under construction to enlarge and afford better facilities to visitors at the free entrance. This will also improve the other portion of the building, to which an admission fee of five cents is charged. Drawings are now being made and methods worked out to replace some of the other unsightly features. All this work should be completed and the apparatus in operation by the spring months.

Park Development Work

My investigation of the various European spas convinced me that no bathing resort can attain to a proper financial success unless it is surrounded by parks, properly designed and made extremely attractive. The value of the mineral water treatments is due not only to the curative properties of the waters, but also to the change of air and the release from home, professional and social duties which are secured by a visit to a health resort. The psychological aspect must be considered and provided for. The State Reservation Commission undoubtedly realized this when they caused the village to provide its unique and beautiful park in the heart of the village, and when it included within the Reservation the High Rock Park, as yet quite too small, the Lincoln Park of 60 acres and the larger Geyser Park of 250 acres, with its exceptional natural advantages of scenery and varied forestation. It would not be effective to make great changes in Geyser Park, and all work done there has been conceived with the idea of intensifying the present natural beauties and making them more evident. To the present plantation has been added the following trees: 40,000 white pines, 20,000 Scotch pines, 8,000 Norway spruce, 1,400 native shrubs and 4,000 arbor vitae.

In order to beautify the grounds adjacent to the Lincoln bath house, considerable planting has been done recently and 5,000

feet of new walks and 5,000 feet of driveway have been constructed. The following trees have been planted: 25,000 Scotch pines, 4,500 Norway spruce, 2,000 populars, 1,600 red cedars, 1,800 white cedars, 2,500 native shrubs, 900 rock maple, 40 dwarf evergreens, 31,000 white pines and 5,000 larches.

About 250 arbor vitae trees have been set out in High Rock Park, and 250 in the Lake Avenue plot, in which are situated the United States and Pavilion Springs.

Scientific Observations, Tests and Experiments

The experiments begun in 1911 to determine the effect of pumping and occurrences following its cessation, as indicated in wells and springs on the properties owned by the Reservation, have been continued throughout the year 1914. The charts of water levels indicate that practically all of the springs have reached their maximum flow and pressure. I should say, judging from these charts, that the springs regained their full strength about six months ago. No changes in water levels have been noted since that time. Tests made at the various wells to determine the amount of free gas available seem to indicate that the gas content is now greater than at any time since the cessation of pumping, and perhaps as great as at any period in the history of the springs. In fact, I have found a few cases where the gas content seems to be greater than at the time pumping started, some years ago, so far as the meager records may be relied upon.

In order to keep down the expenses of the State for improvements, careful investigations were made to discover if possible, some suitable substitute for copper and phosphor-bronze. Dr. Haertl, the expert from Kissingen, recommended that these metals be used for all metal pipes and reservoirs coming into actual contact with the mineral waters. This requires an enormous expense for the installation of a plant where larger copper pipes and tanks are to be used. Careful tests show that steel tanks and large iron pipes, properly coated with a preparation derived from the fractional distillation of coal tar, enable a great saving in cost over copper. It is still deemed desirable to have all small metal pipes made of copper, but larger installation should consist of pipes treated as just stated.

In order to assist in completing the geological charts and data published by the State Museum Department under the direction of Dr. John M. Clarke, the State Geologist, we have taken samples of drillings every ten feet in the bores we are making with the new Keystone driller. These samples are analyzed and a complete record of all rock encountered is made, to be forwarded to Dr. Clarke.

A series of experiments has been carried on to determine the most advantageous pressures and strength of carbonation to be used in bottling certain mineral water. These tests are practically completed and furnish some very interesting and illuminating facts.

Summary and Recommendations

It is, we hope, apparent from the above that during the period covered by this report the engineering staff has made steady progress in the development of the varied problems of the Reservation, and in preparing new designs and carrying on construction work. However, at this writing, we have simply made a substantial start.

There is very much more to be done before this resort can approach the splendors of the European spas. I venture to suggest that future development be directed along such lines that the following results may be accomplished:

A new and properly elaborate bath house, carefully designed and completely furnished, is essential to the successful development of the Spa..

A large and complete drink hall will need to be constructed, and ground for its location must be secured.

There are so many waters of merit within the boundaries of the Reservation that a central bottling works will need to be designed in due time, to be so developed that it would become one of the notable exhibits of the world. I earnestly recommend that plans be worked out for such an establishment. Its development would cost a large amount of money, but it would pay for itself handsomely, and permanently profit the State and the people.

Geological examinations and surveys of underground waters should be made along more extensive lines than before. Certainly the State is to be congratulated upon the amount of data

and statistics which have been compiled, but because of the conditions that have heretofore existed this information must be considered as somewhat superficial and should be regarded as only a foundation upon which to build our future investigations.

It is understood by those who have studied the problem that a park system represents a very slow growth. The beauties of every park are cumulative, and I suggest a plan for improvements to be made from year to year at the Lincoln, Geyser and High Rock parks.

The number of wells drilled into the mineral water reservoir before the formation of the Reservation, by competing exploiters of mineral waters and individuals and corporations seeking supplies of carbonic acid gas, was so unreasonably great that an important part of the work now confronting the Commission is the selection of the best wells and the permanent restoration of the situations of the others to conditions as closely approximating original, natural conditions as possible.

The right foundation is so surely here, the opportunities at Saratoga are so great, and so much has been accomplished that I deem it proper to write, in view of my study of the problem in Europe, that Saratoga Springs ought rightfully to be classed as the greatest Spa in the world, but it cannot be until much larger plans are prepared and generously executed.

Respectfully submitted,

CHAS. G. ANTHONY,

Consulting Engineer.

Report of the Chemist

To the Honorable Commissioners of the Saratoga Reservation:

GENTLEMEN: By reason of my having so recently as October first received the appointment to take charge of your laboratory, my observations will be largely suggestive of what might be done and of improvements, which I think ought to be provided by your Commission, to insure sufficient facilities to accomplish all that is possible and desirable.

The history of the laboratory dates back only to June last, but it is now fairly well equipped to maintain a thorough sanitary control of all the springs of the Reservation. It is already making frequent analyses of the waters of the different mineral springs to determine their exact mineral content, so that the medical profession may be thoroughly informed of the constituents of those that are of medicinal value. There are also additional springs to be studied with reference to further increasing the variety of waters offered. The plan of the State Department of Health in carrying on weekly partial analyses of all the springs has been adopted in order that any serious departure from ordinary conditions may be immediately detected. The laboratory is able to supervise and inspect all waters bottled and placed upon the market for sale.

THE SARATOGA SOFT SWEET SPRING

Through the establishment of the laboratory, it has been made possible to coöperate with the engineering staff and to carry on effectively extensive tests of numerous fresh water springs owned by the State, and thereby to locate a plentiful supply of pure soft water, that will undoubtedly prove to be a source of large revenue and marks a decided step forward in developing the resources of the Reservation.

Development of this water, that meets a long felt need, is now being made; and it will be distributed under the name of "The Saratoga Soft Sweet Spring Water." It is already in demand locally.

The spring is finely located in a thickly wooded ravine, extending from the Willow Gate to the heart of Geyser Park. Along this ravine an attractive footpath will prove most inviting to visitors who will be impressed by the copious supply of cool refreshing water. The surroundings insure the continuance of the fine sanitary qualities of the water with the proper protection as planned; and the great flow of the water during the extreme drought of the past summer vouchsafes a permanent and plentiful supply. The Saratoga Soft Sweet Spring is quite free from minerals, as the upper stratum of sand is entirely sealed off from the more soluble rock below by an impervious table of clay; and the water bubbles forth from the sands which are siliceous and very insoluble in water. In this we have a spring water that is surpassed by none of those on the market in purity, and equalled by few in softness.

The following is the analysis of the Soft Sweet Spring water made at the Reservation laboratory:

The results are expressed in parts per million.

Ions:		Chemical combinations:	
Silica	15.65	Ammonium chloride	trace
Sulphuric acid radicle	9.59	Potassium chloride	.31
Bicarbonic acid radicle	71.33	Sodium chloride	6.35
Nitric acid radicle	.71	Sodium sulphate	10.71
Nitrous acid radicle	trace	Magnesium sulphate	2.94
Chlorine	4.00	Sodium nitrate	.97
Iron and aluminum oxide	.50	Sodium nitrite	trace
Calcium	19.30	Magnesium bicarbonate	14.98
Magnesium	3.08	Calcium bicarbonate	78.04
Potassium	.16	Iron and aluminum oxide	.50
Sodium	6.25	Silica	15.65
Ammonium	.006		
		Total solids in solution, computed	130.45

The bacteriological examination shows the absence of the *B. Coli* type of organism and a total count on gelatine of five per cubic centimeter. The laboratory has approved a temporary method for the proper bottling of the water to supply a per-

sistent immediate demand, until the permanent bottling house can be completed, and will maintain a strict sanitary supervision of all the water dispensed to the public.

Observations on Mineral Springs Made at the Laboratory

The results of the complete analyses made indicate that many of these springs are practically now at the height of their mineralization, as they do not vary much from analyses made for a period of one year and a half previous, and during that time were showing concentrations equal to the present. The Orenda, however, exhibits a marked increase in gas pressure.

The partial analyses made weekly show results that bear out the expressed opinions of the Commission, the Consulting Engineer and Dr. Haertl that, under proper care, the older springs will also gradually attain their former values. A tabulation of some of these results shows a gratifying increase in mineralization, and bears out the supposition that the springs will attain a still greater value.

Results in Parts Per Million

Spring and Date	Chlorine	Chlorine Sodium as Chloride	Alkalinity in terms of Calcium Carbonate
Champion No. 1:			
July 1	640	1055	1180
August 5	960	1584	1510
September 9	1500	2473	1840
October 21	1720	2838	1950
November 27	2080	3432	2100
Geyser:			
July 1	1340	2110	2700
September 2	1420	2341	2800
November 27	1520	2508	2850
Minnonebe:			
July 22	1080	1780	2350
September 21	1320	2178	2650
November 11	1360	2244	2600
Awassa:			
July 1	520	857	1100
August 5	1000	1650	1380
November 27	1200	1980	1440

In making the above tabulation, the date showing the lowest mineralization was selected and then the dates on which there were marked increases were noted until we reached the highest concentration yet obtained. It will be observed that the Champion has increased from month to month, until it has reached a concentration more than 300 per cent. higher than that shown only five months before. This remarkable increase has brought up its mineralization nearly to that shown in Hathorn No. 1, the last tests on Hathorn No. 1 showing a chlorine content of 2360 parts per million and an alkalinity of 2450. While other springs have not exhibited such marked improvement, they are on the upward trend and give every indication of continuing progress. The springs throughout the village are showing a fairly constant mineralization, there being no great changes recorded.

Sanitary Control of the Springs

The sanitary qualities of all the springs in the Geyser Park district justify our expectations, and the same may be said of the village springs, with the exception of the two Red Springs, the use of which has been discontinued, owing to their close proximity to the brook that flows through the heart of the village and necessarily encounters contaminating influences. Analyses of the fresh water supply on the north side of Canfield Park, made on November 16th, show a very low bacterial count, 9 per cc., the *B. Coli* type of organism not appearing. This work was specially important as this water is used extensively by the people of the village, who carry it away in large quantities for use in their homes and offices.

Closing of Springs

There are nearly two hundred wells on the Reservation property and of this number only thirty are allowed to run. Some are hermetically sealed and others are filled with clay. This has been done in accordance with the policy to conserve the gas and to prevent unnecessary depletion of the mineral water basin. Of the wells now flowing, a few will probably be closed upon more complete study.

Testing of Materials

The laboratory has tested chemically materials to be used in the construction and maintenance of the Reservation buildings, such as cement and painting materials. It has tested the crowns used in bottling the waters and phosphor-bronze with reference to its use in the tubing of mineral wells. Owing to the necessity of testing many of the building materials physically, as well as chemically, to insure the best selection for future construction, it is important that certain physical apparatus be now installed. The nature of this should be determined in consultation with the engineer. The amount of construction work planned for the coming year makes the purchase of this apparatus important from the economic standpoint also.

Research Problems

There are now under way in the laboratory the complete analyses of samples of rock strata taken from the new Congress bore at different levels as the drilling proceeds. The object of this is to determine scientifically the nature of the geologic fault, and to plot accurately the depths and the extent of the different strata encountered. This method will be followed for each new bore made. The laboratory will take up an extensive line of experimental work on alloys, for the purpose of finding a suitable, cheap metal, that will withstand the action of the mineral waters and can be used for mineral water tanks and for piping. All problems of research are interesting and more or less valuable. It will be the policy of the laboratory, therefore, to take up such problems of research as are most necessary and of immediate value to the Reservation Commission.

Radio-Activity

It is advisable to install now the necessary apparatus for the determination of the amount of radio-activity in the Saratoga Springs. Radio-activity has been found in the waters of the reservation by U. S. Government chemists, and it is important that the State develop all the knowledge possible as to its extent and therapeutic value. This can only be done by making an exhaustive study of the subject in this laboratory and at the springs.

TOTAL TESTS

Since the establishment of the laboratory last June there has been a total of 1,500 chemical and bacteriological determinations made.

Respectfully submitted,

HERBERT ANT,

January 1, 1915. *Chemist.*

Report of the Secretary

January 1, 1915.

To the Honorable, the Commissioners of the State Reservation:

Gentlemen: I was appointed secretary to your Commission in May last, entering upon my duties on June 1st, since which time I have endeavored to keep in hand the manifold details which the development of the Reservation has produced. I am familiar with some of the requirements which such an important development suggests, inasmuch as I have had several years' experience in the marketing of waters sold for drinking purposes. I have, therefore, as directed by you, given constant thought to that aspect of the problem in your hands, making as careful study as time would allow of the various questions connected with the traffic in cathartic waters and carbonated table waters. Since the development of the *Saratoga Soft Sweet Spring Water,* which is so exceptionally promising as a marketable table water, I have perhaps the more readily been able to associate this problem with my previous experience.

I realize, of course, that it was not possible to keep up-to-date, in many particulars, the methods used at the numerous isolated plants for bottling the waters of the Reservation. I have found, as anticipated, that a proper and full consideration of these questions will suggest important economies in the administration of the water problems and should facilitate the preparation of this product of the Reservation to properly meet a constantly increasing demand, and also should indicate the true and very great possibilities of the waters when properly exploited.

The matter I deem of first importance is the introduction of more modern and hygienic methods of bottling and the installation of machinery and other equipment for a more satisfactory performance of certain operations heretofore done by manual labor. These improvements should result not only in a reduction of operating expenses but in the production of the finest quality of waters.

Some of these improvements have been made during the year and within the limit of available funds; others are now in progress and being planned. In view, however, of the present unsuitable and inadequate buildings, such improvements must of necessity be partial, reserving the larger and more up-to-date appliances for installation in the new bottling plant which the State should erect in the near future,— one large enough to permit of the bottling therein of all the waters of the Reservation. Carrying of all waters in pipes to, and the bottling of same in, one building will reduce greatly the initial cost to the State of providing more sanitary methods for the bottling of its various waters. The Hathorn No. 2, Orenda and Coesa waters are now piped to the Geyser building, which has been remodeled to a certain extent and additional machinery and appliances installed, making it possible for us now to bottle in that building, under improved sanitary conditions, the five mineral waters heretofore bottled in three separate buildings. Aside from the advantages of improved bottling methods and general increased efficiency, this centralizing of our bottling in the largest convenient building now owned by the State, but which is still not large enough, will result in a reduction in operating expenses of about 40 per cent.

In September last I made a personal canvass among acquaintances and important business houses and hotels in New York City dealing in such waters. All expressed approval of the State's acquisition of the mineral springs now under its control and offered their full support to the efforts of the Commission, conditional, however, upon the State's first securing through advertising and otherwise the renewal of a general demand for these restored waters, as the call for them has naturally well nigh vanished during the years of their absence from the market. I beg, therefore, to emphasize the vital importance of your appropriating sufficient funds for advertising the advantages of the State waters and the fact of their availability to the public through the medium of bottles filled and sealed under sanitary precautions. The same advertisements could set forth further their modern use in the State bath houses at Saratoga Springs, conducted under the supervision of the State Commission. The advantages now assured cannot fail to produce confidence because of the official staff composed of experts

I would respectfully suggest to the Commission that serious consideration be given to the matter of establishing for a period of one year, for more effective advertising, suitable headquarters in the uptown section of New York City, with display windows facing if possible upon Broadway or Fifth Avenue, in which to exhibit bottled waters, photographs, models of our natural spouting springs, bath houses, etc., and for the proper conduct from same of a vigorous campaign in the interest of Saratoga Springs as a Health Resort. The cost of maintaining such an office in New York City for the next year need not exceed $10,000, depending, of course, upon the location selected. Such an expenditure would assist greatly in establishing the business on a permanent basis. It would not be advisable for the Commission to make a lease of the marketing privileges of these waters for a period of years until such necessary advertising shall have been done. Through the immediate prosecution of such a campaign it is safe to say that the Commission would be in position to enter into such an arrangement at the end of the year 1915.

In conducting its advertising campaign next year the Commission should lay great stress upon, and make most emphatic announcement to the public that all of the mineral waters offered for sale under the State seal are *natural mineral waters, with natural carbonic acid gas,* to which no ingredients whatever have been added, and thus correct a misunderstanding of the facts that now exists in the minds of many.

Respectfully submitted,

LOUIS W. NOLAND,

Secretary.

PAYMENTS FROM SARATOGA SPRINGS RESERVATION FUND

UNDER CHAPTER 394, LAWS OF 1911, AND CHAPTER 239, LAWS OF 1913

Appropriation, purchase of land	$950,000 00

FINANCIAL STATEMENT

CHAPTER 239, LAWS OF 1913

(Re-appropriation of Balance from Chapter 394 of 1911.)

Balance, January 1, 1914 (per last report)			$399,353 28
Feb.	5. Emily H. Hathorn, of Hathorn & Co., Florence Hathorn and A. L. Allerdice, administratrices of estate of Frank H. Hathorn, deceased, for property	$225,000 00	
	Emily H. Hathorn et al., interest	40,125 00	
	19. Amy A. Clark, for property	8,500 00	
	Amy A. Clark, interest	1,279 25	
March	20. C. S. & C. C. Lester, legal services	332 50	
May	27. Ida E. Traver, for property	7,000 00	
	Ida E. Traver, interest	1,113 00	
	Fred Dingman, for property	4,750 00	
June	3. J. S. Mott & Son, services as civil engineers	75 82	
	C. S. & C. C. Lester, legal services	884 95	
July	3. Edward Croker, for property	16,000 00	
	Edward Croker, interest	2,122 67	
	C. S. & C. C. Lester, legal services	1,199 00	
Aug.	27. C. S. & C. C. Lester, legal services	596 00	
	31. Charlesanna L. Huston, for property and surveys, etc.	5,679 75	
	Charlesanna L. Huston, interest	126 85	
Oct.	1. J. B. Bailey, services as appraiser	20 00	
	L. M. Jones, services as appraiser	20 00	
	W. S. Lefler, services as appraiser	40 00	
	Willard Lester, services as appraiser	83 00	
	28. Village of Saratoga Springs, for property	5,000 00	
	Village of Saratoga Springs, interest	348 33	
	C. S. & C. C. Lester, legal services	778 50	
			$321,074 62
	Balance, January 1, 1915		78,278 66

CHAPTER 547, LAWS OF 1912

Secretary's Salary

Balance, January 15, 1914			$566 68
March 2.	I. G. Rouillard, services, January	$200 00	
25.	I. G. Rouillard, services, February	200 00	
April 20.	I. G. Rouillard, services, March, partial	166 68	
			$566 68

Secretary's salary for balance of year paid from Chapter 252, appropriated for General Expenses.

CHAPTER 435, LAWS OF 1913

General Expenses

1914.			
Jan. 15.	Balance		$5,716 62
22.	Payrolls, High Rock and Geyser Parks	$228 85	
Feb. 11.	Payrolls, High Rock and Geyser Parks	211 30	
March 2.	Payrolls, High Rock and Geyser Parks	159 77	
	Aird-Don Co., pipe	62 53	
	L. Betts, well drilling	375 00	
	Buhring Water Purifying Co., supplies	164 90	
	A. L. Churchill, receiver of taxes, taxes	68 50	
	C. M. Collins, furniture	32 50	
	C. H. R. Compton, operation of Magnetic Baths	236 33	
	D. Eddy & Sons, grass seed	35 05	
	Dr. A. W. Ferris, medical expert, services	916 66	
	J. H. Gleason, plumbing	7 90	
	J. Mangelsdorf, seed bags	47 28	
	J. S. Mott & Son, surveys and maps	43 76	
	National Express Co., express	26 24	
	N. Y. Telephone Co., telephone and telegrams	25 76	
	Commissioner G. F. Peabody, office expenses	70 52	
	Commissioner G. F. Peabody, travel	17 64	
	I. G. Rouillard, secretary, travel	54 08	
	The Saratogian, printing	17 50	
	H. B. Settle, photographs	30 40	
	G. F. Shelvin Mfg. Co., labor	19 80	
	Sun Printing Co., printing	15 82	
	Ten Eyck Co., travel	23 30	

1914.				
March	2.	Van Voast & Leonard, insurance....	$4 50	
		A. Wyckoff & Son, wooden pipe....	14 71	
	16.	Payrolls, High Rock and Geyser Parks	196 50	
	25.	C. G. Anthony, consulting engineer, services and expenses.....	238 15	
		Farmers' Hardware Co., supplies...	20 46	
		Dr. A. W. Ferris, medical expert, services	916 67	
		W. M. Ingmire, plumbing.....	62 00	
		National Express Co., express.....	8 26	
		N. Y. Telephone Co., telephone and telegrams	34 61	
		E. R. Todd, supplies.....	2 75	
		Wittemann Bros., supplies.....	7 80	
	31.	Payrolls, field forces and laborers...	196 50	
April	16.	Payrolls, field forces and laborers...	270 90	
				$4,865 20
		Balance		$851 42

CHAPTER 46, LAWS OF 1914

General Expenses

Appropriation				$10,000 00
Balance transferred from Chapter 435, Laws of 1913.....				851 42
1914.				$10,851 42
April	20.	I. G. Rouillard, secretary, services, balance due March.....	$33 32	
		C. G. Anthony, consulting engineer, services, expenses	285 44	
		Argus Co., printing.....	34 00	
		Baker-Vawter Co., supplies.....	7 30	
		Dr. Simon Baruch, consulting expert, expenses	60 00	
		H. Crocker, improvements.....	8 28	
		E. B. Davis, rodman, travel.....	2 10	
		Dr. A. W. Ferris, medical expert, services	916 67	
		U. T. Hungerford Co., copper pipe...	143 30	
		F. P. Langley, axeman, travel.....	4 60	
		N. Y. Telephone Co., telephone, telegrams	19 96	
		Commissioner G. F. Peabody, office expenses	26 39	
		The Saratogian, printing.....	14 50	
		H. B. Settle, photographs.....	16 60	
		G. F. Shelvin Co., supplies.....	7 70	
		W. P. Tarrant, plumbing.....	664 45	

1914.			
April	20. Ten Eyck Co., travel	$56 50	
	Towne–Roblee Hardware Co., supplies	10 76	
	G. W. Winship, improvements, (concrete)	26 10	
	A. Wyckoff & Son Co., wooden pipe	8 62	
	24. Payrolls, office and field forces	282 38	
May	8. Payrolls, office and field forces	758 70	
	20. I. G. Rouillard, secretary, services and travel, April	204 36	
	C. G. Anthony, consulting engineer, services and travel, April	293 15	
	J. A. Bensel, State Engineer, surveys	213 44	
	B. Brunner, stationery supplies	128 87	
	W. J. Case & Son, improvements (carpentry)	166 00	
	Collins & Spencer, improvements (plumbing)	72 05	
	Crosby Steam Gage Co., supplies	4 69	
	John W. Emery, supplies	7 50	
	E. Ermold Co., supplies	26 08	
	Farmers' Hardware Co., supplies	31 88	
	Goulds Mfg. Co., supplies	12 15	
	Dr. A. W. Ferris, medical expert, services	916 67	
	J. F. Hennessy, county clerk, services	1 00	
	Hoyt Bros. Co., supplies	68 00	
	U. T. Hungerford Co., copper pipe	730 83	
	C. J. Lundgren, supplies	8 10	
	National Express Co., express	20 79	
	N. Y. Telephone Co., telephone, telegrams	39 95	
	T. C. Schallehn, improvements	20 25	
	Stone & Morris, livery	8 00	
	Sun Printing Co., office printing	50 00	
	W. P. Tarrant, plumber, supplies and services	86 83	
	H. H. Tedford, improvements, Geyser Park	230 00	
	Towne, Roblee Hardware Co., supplies	13 26	
	Commissioner B. F. Tracy, travel	37 78	
	A. Wyckoff & Son Co., wooden pipe	33 03	
	N. Y. Belting & Packing Co., supplies	22 80	
	21. Payroll, May 1–15, office and field forces	872 24	
June	10. Payroll, May 16–30, office and field forces	552 00	
			8,259 37
	Balance		$2,592 05

CHAPTER 252, LAWS OF 1914

General Expenses and Land Acquisitions

Appropriation		$235,000 00
Balance transferred from Chapter 46, Laws of 1914		2,592 05
1914.		$237,592 05
June 26. Payrolls, June 1–15, office and field forces	$492 00	
C. G. Anthony, consulting engineer, services and expenses, May	240 00	
I. J. Burdick, insurance	12 50	
E. B. Davis, rodman, travel	3 45	
D. Eddy & Son, Inc., supplies	12 00	
Farmers' Hardware Co., supplies	28 30	
Dr. A. W. Ferris, medical expert, services, May	833 33	
L. O. Hall, trees	9 15	
Hartwell & Shackelford, insurance	115 99	
U. T. Hungerford Co., copper pipe	706 02	
C. S. & C. C. Lester, legal services, and expenses	4,266 47	
J. Manglesdorf, seed bags	20 00	
J. D. McNulty, insurance	438 98	
National Express Co., express	8 40	
N. Y. Telephone Co., telephone, telegrams	40 81	
Commissioner G. F. Peabody, office expenses	49 00	
I. G. Rouillard, secretary, travel	30 45	
Security Steel & Iron Co., supplies	25 04	
H. B. Settle, photographs	7 00	
G. F. Shelvin Mfg. Co., supplies	4 05	
W. J. Thompson, chemist, travel	6 65	
Ingham, White & Co., insurance	37 50	
Van Voast & Leonard, insurance	27 75	
G. W. Winship, improvements (concrete)	38 38	
July 6. Payrolls, June 16–30, office and field forces	511 05	
21. Payrolls, July 1–15, office and field forces	582 50	
30. C. G. Anthony, consulting engineer, services, June	260 00	
Adirondack Electric Power Corp., supplies	7 81	
Argus Co., stationery, supplies	50 00	
J. A. Bensel, State Engineer, services, expenses	256 45	
Bernard Brunner, stationery supplies	41 23	

1914.

July	30.	Buhring Water Purifying Co., supplies	$70 00
		Cook Motor Co., gasoline engine	758 50
		Harry Crocker, improvements (carpentry)	596 93
		E. C. Eaton, trucking	30 50
		C. B. Elmore, services and travel, June	94 65
		Eimer & Amend, laboratory supplies	62 34
		The Fairbanks Co., supplies	6 09
		Dr. A. W. Ferris, medical expert, services, June	833 33
		Gage & Perry, travel	37 10
		Gallagher Bottle Machinery Co., supplies	35 00
		Goulds Mfg. Co., machinery	546 00
		C. E. Hall, well expert, travel	4 80
		U. T. Hungerford Brass & Copper Co., copper pipe	952 88
		L. O. Koven Bros., supplies	58 00
		C. C. Lester, legal services and expenses	1,509 65
		J. Mangelsdorf, seed bags	15 00
		John McNeary & Sons, livery	9 00
		Wm. C. McQueen, well drilling	305 00
		N. Y. Telephone Co., telephone	30 35
		Commissioner G. F. Peabody, travel	22 53
		Commissioner G. F. Peabody, office expenses	233 19
		Christian Pederson, services and supplies	8 45
		John Peterson, landscape gardener, services and travel	90 00
		Reeves–Reagan Co., improvements	119 50
		Saratoga Coal Co., supplies	5 50
		T. C. Schallehn, improvements	10 45
		Scientific Materials Co., laboratory supplies	406 11
		Sherin & Son, improvement (electrical)	51 65
		Geo. F. Shelvin Mfg. Co., improvements	140 18
		D. Stever, trucking	98 50
		Stone & Morris, livery	4 00
		W. P. Tarrant, improvement (plumbing)	179 02
		Wm. J. Thompson, chemist, travel	12 60
		J. S. Turner, supplies	2 60

1914.

July	30.	Western Union Telegraph Co., telegrams	$12 77
		A. Wyckoff Son Co., wooden pipe	178 21
Aug.	5.	Payroll, July 16–31, office and field forces, laborers, etc	685 33
	20.	Payroll, Aug. 1–15, office and field forces	656 63
	26.	Adirondack Electric Power Corp., electric current	21 74
		E. A. Andrus, roof repaired and painted, 3 years' guarantee	300 00
		C. G. Anthony, consulting engineer, services and expenses, July	273 90
		Baker & Co., Inc., laboratory supplies	639 24
		F. E. Brickner & Co., improvements (electrical)	132 30
		Burleigh Lithographing Co., printing	77 42
		Bernard Brunner, stationery supplies	56 73
		Harry Crocker, improvement (carpentry)	207 59
		Crown Cork & Seal Co., supplies	26 78
		Elvin C. Eaton & Son, trucking	26 25
		Arthur R. Eaton, livery	6 00
		Excelsior Wrapper Co., supplies	28 83
		Farmers' Hardware Co., supplies	8 51
		Earl B. Davis, rodman, travel	1 65
		Dr. A. W. Ferris, medical expert, services	833 33
		B. Gaffney & Sons, Improvement, (concrete)	27 65
		General Carbonic Co., supplies	27 50
		Frank H. Handy, improvement, (painting)	46 00
		Hartwell & Shackelford, insurance	100 23
		Ingham White & Co., insurance	58 50
		Lewis M. Jones Co., insurance	12 50
		Carl J. Lundgren, improvement	7 35
		J. Mangelsdorf, seed bags	15 65
		National Express Co., express	11 90
		N. Y. Telephone Co., telephone	2 00
		Commissioner G. F. Peabody, office expenses	139 39
		Commissioner G. F. Peabody, travel	11 00
		John Peterson, landscape gardener, services and travel	25 50
		C. F. Rattigan, Warden, Auburn Prison, supplies	75 20
		Reeves–Reagan Paint Co., signs	30 00

1914.		
Aug. 26.	James A. Ryall, improvement, (plumbing)	$235 61
	Sherin & Son, improvement, (electrical)	241 90
	Geo. F. Shevlin Mfg. Co., improvement	26 50
	Scientific Material Co., laboratory supplies	97 20
	Stone & Morris, livery	8 00
	Wm. P. Tarrant, improvement, (plumbing)	832 30
	Wm. J. Thompson, chemist, travel	1 70
	Towne-Roblee Hardware Co., supplies	23 84
	West Disinfecting Co., supplies	5 00
	George W. Winship, improvement (concrete)	99 62
	John McNeary & Sons, livery	52 00
	Van Voast & Leonard, insurance	27 75
	Western Union Telegraph Co., telegrams	2 81
Sept. 3.	Payroll, August 16–31, office and field forces	680 65
23.	Payroll, September 1–15, office and field forces	764 72
Oct. 7.	Payroll, September 16–30, office and field forces	1,191 07
5.	Adirondack Electric Power Corporation, electric current	32 12
	Charles G. Anthony, consulting engineer, services, August	240 30
	The Argus Co., supplies	52 80
	P. Blakistons Sons & Co., supplies	5 00
	Bernard Brunner, stationery supplies	27 32
	A. L. Churchill, receiver of taxes, taxes	199 28
	The Crown Cork & Seal Co., supplies	90 69
	E. C. Eaton & Son, trucking	47 25
	Eimer & Amend, laboratory supplies	77 18
	Cyrus B. Elmore, travel	4 00
	Federal Printing Co., printing	65 00
	Dr. A. W. Ferris, medical expert, services	833 33
	The Goulds Mfg. Co., machinery	260 25
	Charles E. Hall, well expert, travel	3 90
	Frank H. Handy, supplies	2 70
	Hoyt Bros. & Co., supplies	14 00
	Samuel J. Mott, blue prints, etc	7 31
	John McNeary & Sons, livery	6 00
	Wm. McQueen, well drilling	100 75
	N. Y. Telephone Co., telephone	12 07

1914.

Oct. 5.	The New York Times, advertising....	$5 00
	Louis W. Noland, secretary, travel...	1 50
	James Paul, trees.....	183 60
	Commissioner Geo. Foster Peabody, office expenses	108 77
	Commissioner Geo. Foster Peabody, travel	6 00
	The Reeves–Reagan Paint Co., Inc., supplies	13 60
	James A. Ryall, improvement, (plumbing)	34 19
	Saratoga Coal Co., supplies.....	6 60
	Saratoga Woodcraftsmen, Inc., supplies	68 16
	T. C. Schallehn, supplies.....	2 70
	Scientific Materials Co., laboratory, supplies	87 10
	Stone & Morris, livery.....	3 00
	Walter M. Stroup, supplies.....	6 45
	Tarrant Mfg. Co., supplies.....	11 50
	Wm. J. Thompson, chemist, travel..	1 50
	Towne–Roblee Hardware Co., supplies	43 17
	Commissioner Benjamin F. Tracy, travel	57 66
	Philip S. Wakeley, advertising.....	15 00
	Western Union Telegraph Co., telegrams	3 81
29.	Charles G. Anthony, consulting engineer, services and travel, Sept...	321 00
	Bernard Brunner, stationery supplies	9 85
	Harry Crocker, supplies	143 53
	The B. F. Cummins Co., machinery..	50 00
	E. C. Eaton & Sons, trucking.....	33 25
	Eimer & Amend, supplies, laboratory	27 35
	C. B. Elmore, travel.....	5 30
	The Farmers Hardware Co., supplies.	75 58
	Dr. A. W. Ferris, medical expert, services and expenses.....	976 73
	Robt. M. Fitzmaurice, services and expenses at exhibit at State Fair....	65 95
	Hartwell & Shackelford, insurance..	148 75
	O. V. Howland, insurance.....	45 00
	Independent Coal Co., supplies.....	8 40
	A. P. Knapp, insurance.....	43 22
	Charles C. Lester, legal services.....	750 00
	John McNeary & Sons, livery.....	21 50
	Wm. McNeary, livery.....	5 00
	National Express Co., express.....	32 16
	N. Y. Evening Post, advertising....	176 40

1914.			
Oct.	29.	N. Y. Telephone Co., telephone.....	$26 24
		Commissioner Geo. Foster Peabody, office expenses	165 98
		Commissioner Geo. Foster Peabody, travel	1 50
		John Peterson, landscape gardener, services and travel.....	73 50
		James A. Randall, Syracuse Fair Exhibit	265 85
		The Reeves–Reagan Paint Co., supplies.	22 50
		Ross–Ketchum Co., supplies.....	13 35
		James A. Ryall, improvements, (plumbing)	61 62
		Scientific Materials Co., laboratory supplies	16 50
		H. B. Settle, photographs.....	111 55
		J. A. Sigsby, painting.....	498 00
		Stone & Morris, livery.....	5 00
		Wm. P. Tarrant, improvements and supplies	285 37
		Underwood Typewriter Co., Inc., supplies	87 08
		Van Voast & Leonard, insurance....	18 45
	31.	Payroll, October 1–15, office and field forces	1,731 89
Nov.	11.	Payroll, October 16–31, office and field forces	1,877 94
	21.	Payroll, November 1–15, office and field forces	2,037 18
Dec.	3.	Adirondack Electric Power Corporation, electric current.....	56 99
		Charles G. Anthony, consulting engineer, services and travel, October	377 41
		The Argus Co., stationery supplies...	31 86
		Berkefield Filter Co., supplies.....	17 50
		Davis Bradley, trucking.....	9 50
		Bernard Brunner, stationery supplies	13 46
		H. H. Coots, trees.....	42 78
		Harry Crocker, improvements, (carpentry)	1,098 34
		Elvin C. Eaton & Son, trucking.....	24 00
		Daniel Eddy & Sons, supplies.....	10 56
		Eimer & Amend, laboratory supplies	68 23
		John W. Emery, supplies.....	8 00
		August Erickson, trees.....	108 38
		The Farmers Hardware Co., supplies	9 23
		Dr. A. W. Ferris, medical expert, services and expenses.....	929 02

1914.		
Dec. 3.	The Goulds Mfg. Co., machinery.....	$147 24
	George Groff, trees.....	17 50
	W. & L. E. Gurley, field equipment..	158 10
	Charles E. Hall, well expert, travel..	2 30
	Hayes & Prescott, signs.....	33 30
	D. H. Henry, trees.....	240 00
	Kewanee Private Utilities Co., machinery	742 00
	Keystone Driller Co., drill and machinery	2,019 24
	L. O. Koven & Bro., supplies.....	116 00
	P. Leonard, town superintendent, services	3 00
	John McNeary, livery.....	16 50
	National Express Co., expressage....	8 76
	N. Y. Telephone Co., telephone.....	15 68
	The New York Times Co., advertising	175 50
	Clarence R. Parmenter, improvements (carpentry)	185 92
	James Paul, trees.....	403 50
	John Peterson, landscape gardener, services and expenses.....	104 00
	Commissioner Geo. Foster Peabody, office expenses	404 80
	Robson & Adee, furniture.....	62 00
	Ross-Ketchum Co., supplies.....	11 10
	James A. Ryall, improvements (plumbing)	555 80
	Saratoga Coal Co., supplies.....	31 50
	The Saratogian, printing.....	114 00
	Henry Senecal, trees	23 16
	E. D. Starbuck & Co., supplies.....	54 00
	State Insurance Fund, insurance.....	22 30
	The Sun Printing Co., printing.....	14 74
	Sun Printing & Publishing Co., advertising	180 00
	Wm. P. Tarrant, supplies.....	23 61
	The Tribune Association, advertising.	175 00
	R. H. Thompson, painting.....	388 09
	Wm. J. Thompson, chemist, travel...	1 40
	T. Tooley, trucking.....	8 00
	Towne-Roblee Hardware Co., supplies	44 78
	Western Union Telegraph Co., telegrams	12 97
	Fred C. White, supplies.....	28 56
12.	Payroll, November 16-30, office and field forces	2,224 41

1914.			
Dec.	23.	Payroll, December 1–15, office and field forces	$2,990 60
1915.			
Jan.	6.	The Argus Co., printing	84 12
		Charles G. Anthony, consulting engineer, services and travel	367 18
		Ballston Spa Garage Co., 1½-ton Mack truck, with specially designed top	2,549 00
		Ballston Spa Garage Co., trucking	47 40
		The Blake & Knowles Steam Pump Works, machinery	364 00
		Chas. A. Brassler, services	51 11
		F. W. Brownell, travel	8 00
		F. W. Brownell, trucking	40 50
		F. W. Brownell, trucking	29 25
		F. W. Brownell, supplies	22 50
		Bernard Brunner, supplies	23 96
		C. P. Coleman & G. M. P. Murphy, receivers, machinery	223 00
		H. H. Coots, trees	91 86
		Harry Crocker, improvements	145 74
		Delaware & Hudson Co., freight	274 21
		R. E. Dennin, services	15 00
		Henry Dooney, fence wire	14 40
		E. C. Eaton, trucking	1 50
		C. B. Elmore, travel	5 70
		John W. Emery, supplies	8 00
		August Erickson, trees	259 95
		Edward Ermold Co., labeling machine	441 00
		The Farmers Hardware Co., supplies	8 34
		Dr. Albert Warren Ferris, medical expert, services	833 33
		Dr. Albert Warren Ferris, travel	65 54
		The Goulds Mfg. Co., machinery	725 90
		Will W. Gregory, supplies	8 00
		Hartwell & Shackelford, insurance	3 30
		D. H. Henry, trees	30 00
		U. T. Hungerford Brass & Copper Co., copper pipe	463 56
		Independent Coal Co., supplies	84 20
		Ingham, White & Co., insurance	71 82
		Wm. H. Lane, supplies	25 00
		H. E. Lesan Adv. Agency, Inc., advertising	220 80
		C. S. & C. C. Lester, legal services and expenses	1,505 37
		Carl J. Lundgren, improvements	17 00
		John McNeary & Sons, livery	3 75

1915.		
Jan. 6.	James Morrissey, improvements	$95 73
	Samuel J. Mott, blue prints, etc.	24 12
	National Express Co., express	7 75
	N. Y. Telephone Co., telephone	16 25
	Louis W. Noland, secretary, travel	23 26
	James Paul, trees	111 60
	F. H. Partridge, fire extinguishers	7 50
	Commissioner Geo. Foster Peabody, office expenses	161 55
	Commissioner Geo. Foster Peabody, travel	15 35
	John Peterson, landscape gardener, services	69 00
	John Peterson, landscape gardener, supplies	130 00
	The Reeves-Reagon Co., improvements (painting)	438 90
	Ross-Ketchum Co., Inc., supplies	2 45
	Irving G. Rouillard, special services	64 40
	James A. Ryall, improvements, (plumbing)	59 25
	Salem Glass Works, bottles	742 50
	Saratoga Coal Co.	69 50
	H. B. Settle, photographs	55 05
	Sherin & Son, improvement (electrical)	121 81
	Geo. F. Shelvin Mfg. Co., supplies	43 55
	J. A. Sigsby, improvement, (painting)	14 00
	Oscar R. Stenstrom, bath master, services	319 50
	Stone & Morris, livery	20 00
	Wm. P. Tarrant, improvement, (plumbing)	31 28
	E. R. Todd, supplies	4 20
	T. J. Totten, Inc., supplies	5 00
	Van Voast & Leonard, insurance	108 25
	Western Union Telegraph Co., telegrams	8 20
	Fred C. White, bottles	109 76
	Geo. W. Winship, supplies	36 50
	Geo. W. Winship, concrete swimming pools	988 86
	A. Wyckoff Son Co., wooden pipe	2,969 46
	A. Wyckoff Son Co., wooden pipe	908 32
	Henry R. Worthington, machinery	802 00
8.	Payroll December 16-31, laborers	1,010 51
19.	C. G. Anthony, consulting engineer, services and travel	354 37
	Argus Co., printing	49 03

1915.		
Jan. 19.	J. A. Beyer, supplies	$3 50
	Bernard Brunner, stationery supplies.	30 17
	Chase Bros. Co., trees	41 85
	H. H. Coots, trees	12 00
	F. M. Crawford, services	10 00
	Harry Crocker, improvements (carpentry)	50 20
	Delaware & Hudson Co., freight	60 82
	Arthur R. Eaton, livery	6 75
	Elvin C. Eaton, trucking	1 00
	Daniel Eddy & Sons, Inc., supplies	9 00
	Eimer & Amend, laboratory supplies	169 29
	Cyrus B. Elmore, travel	3 10
	August Erickson, trees	50 25
	Farmers Hardware Co., supplies	32 94
	Dr. Albert Warren Ferris, medical expert, services, supplies and travel	841 19
	B. Gaffney & Sons, improvements (concrete)	510 30
	Goulds Mfg. Co., machinery	474 00
	Commissioner Frank N. Godfrey, travel (Oct., 1912 to Jan. 1915)	459 67
	Will W. Gregory, supplies	8 00
	Charles E. Hall, well expert, travel	3 20
	Independent Coal Co., supplies	82 25
	Keystone Driller Co.	84 78
	J. B. Lyon Co., stationery	50 00
	J. Mangelsdorf, supplies	7 00
	Samuel J. Mott, blue prints	8 88
	National Express Co., express	15 58
	N. Y. Continental Jewell Filtration Co., filtering equipment	975 00
	N. Y. Telephone, telephone	24 99
	Louis W. Noland, secretary, travel	2 97
	John Peterson, landscape gardener, services	78 00
	John Peterson, landscape gardener, travel	7 50
	Commissioner G. F. Peabody, office expenses	73 66
	C. F. Rattigan, Warden, Auburn Prison, supplies	32 50
	Reeves-Reagan Paint Co., supplies	12 60
	Ross-Ketchum Co., supplies	14 58
	James A. Ryall, improvements	17 12
	Salem Glass Works, water cases	240 00
	The Saratogian, printing	13 25
	Saratoga Coal Company, supplies	59 25
	T. C. Schallehn, supplies	35 80

1915.				
Jan.	19.	H. B. Settle, photographs	$53 30	
		Sherin & Son, supplies	3 05	
		E. D. Starbuck & Co., supplies	70 00	
		Stone & Morris, livery	15 25	
		Wm. P. Tarrant, improvements, (plumbing)	430 00	
		Wm. H. Thomas Monument Co., marble	150 00	
		Towne–Roblee Hardware Co., supplies	48 01	
		Commissioner B. F. Tracy, travel	28 63	
		S. Twitchell Co., storage tanks	780 00	
		Western Union Telegraph Co., telegrams	7 04	
		Geo. W. Winship, improvements, (concrete)	325 17	
		Wittemann Bros., supplies	12 90	
		Herbert Ant, chemist, travel	2 20	
	20.	Payroll, December 16–31, office and field forces	738 89	
				$79,508 99
		Balance, January 20, 1915 (after paying December bills)		$158,083 06

Receipts to December 31, 1914

March	25.	E. C. Eaton, sale of building	$110 00
April	4.	Wallace White, rent (February, March and April)	18 00
May	2.	H. H. Tedford, rent (February 1 to March 15)	9 05
		J. G. Foulkes, rent (February and March)	20 00
		Wallace White, rent (May)	6 00
		Arthur G. Qua, iron pipe	11 60
	4.	B. Gordon, scrap iron	17 00
June	10.	Wallace White, rent (June)	6 00
	26.	Leslie A. Cook, bottle caps	10 30
July	3.	Phineas Smith, hay	7 00
		Wallace White, rent (July)	6 00
July	31.	Adirondack Elec. Power Corporation, 4 Elm trees	14 00
		Wm. C. McQueen, pump barrel	10 00
Aug.	31.	Wallace White, rent (August)	6 00
Sept.	2.	Davis Bradley, 1 out-house	2 00
Oct.	6.	Wallace White, rent (September)	6 00
Sept.	17.	Elvin C. Eaton, sale of Congress Spring pavilion	50 00
Sept.	28.	Elvin C. Eaton, Sale of Dingman house	225 00
Oct.	9.	A. Lavine, sale 2 buildings	212 50
	16.	Abe Cooper, scrap iron and old belting	188 00
Nov.	3.	Wallace White, rent (October)	6 00
Oct.	6.	Receiver of Taxes, over-payment of water tax (High Rock Bath)	20 18

Nov.	28.	Wm. C. McQueen, 1 3-inch x 6-inch strainer, 1 6-inch x 6-inch strainer	$16 40
Nov.	30.	F. H. Partridge, Commission on sanitary cup sales	34 69
		F. H. Partridge, 2 5-gal. demijohns crated	2 00
Dec.	12.	Robson & Adee, Commission on sanitary cup sales	71 66
			$1,085 33

Remittances to Comptroller

1914.		
April	4	$128 00
May	5	63 60
Aug.	5	53 30
Nov.	11	715 68
Dec.	18.	124 75
		$1,085 33

STUDY OF THE HYDRAULICS OF THE MINERAL WATER SYSTEM AT SARATOGA SPRINGS

By CHARLES C. LESTER, A.M.,
Saratoga Springs, N. Y.
Counsel to the Commissioners of the State Reservation

Prefatory Remarks. It may seem presumptuous for one who is by profession neither a chemist, geologist nor hydraulic engineer to express opinions upon a subject that involves the science of each of these professions, and has given rise to profound conflicts of opinion. It happens, however, not infrequently, I think, that an indifferent mind, by utilizing facts furnished by others and acquired by a special skill and knowledge beyond its own, may reach correct conclusions which those whose vision is habitually restricted to the horizon of a single branch of learning may be much slower in reaching or perhaps may never reach at all.

It is the business of a lawyer to co-ordinate conflicting opinions, and it should be his highest aim from a multitude of such opinions to learn wisdom. It is in this spirit I have taken up the study of the present subject.

If further apology should be needed, it might be found in the fact that for a long period of years my attention has been specially directed to this subject. I drew the so-called anti-pumping law in 1908 (Laws 1908, chap. 429) at the request of the "Citizens' Committee," an organization whose object was to rescue the mineral springs of Saratoga, which its members rightly esteemed one of the great natural resources of the State, from threatened extinction. I advocated its passage before legislative committees and before the Governor, and have participated in all the litigation which followed and which involved the question of its constitutionality, both in the State courts and in the courts of the United States. I have thus had an opportunity to meet, confer with and question many very eminent experts who have expressed opinions upon the subject, when I encountered them upon the witness stand and in private conference. As counsel to the Commissioners of the State Reservation, after the State came into possession of the mineral water springs and wells at Saratoga,

I gave general directions as to the collection of scientific data relating to the mineral water supply which I thought might be of service to them later, and I have had the satisfaction of knowing that, besides the deep scientific interest that attaches to the data thus obtained, they are likely to serve the main purpose for which they were collected.

Topography. In studying the hydraulics of the mineral water system that supplies the springs and wells of Saratoga, it is necessary to consider briefly the topographical features of the districts in which the springs appear, as the topography has much to do with the location of the springs and is always involved in every discussion of the phenomena.

The Saratoga Plateau. The first thing to be noted in this connection is the existence of an elevated plain upon which a large part of the village of Saratoga Springs is built and which extends, for a considerable distance, in every direction but the north from the Congress Spring. This plain is about forty feet above the point of overflow of the Hathorn Spring, and a much greater height above the water courses which bound it on the south and the mouths of many of the wells in the Coesa valley. The northern boundary of this elevated plain or plateau, from a point at or near the Red Spring to a point beyond the Eureka Spring, a distance of approximately a mile and a half, may be considered to be the water course known as the "Village Brook;" the eastern boundary, the low lands known as the "Great Bear Swamp" through which the Village Brook flows as it turns southward, upon which boundary the plateau fronts for a distance of three or four miles. The southern boundary is the valley of the Kayaderosseras creek, and the western boundary the valley of the Coesa and its northern Tributary, Slade's brook, which sweeps around to the eastward, as you ascend it, thus forming part of the northern boundary. But, between the head waters of the Slade brook and the Red Spring, there is a higher elevation on which the northerly part of the village and Woodlawn park are found. This elevation is the southernmost and lowest hill or mountain in the Palmertown range.

This plateau, everywhere above the water courses and lowlands which we have mentioned as forming its boundaries, connects

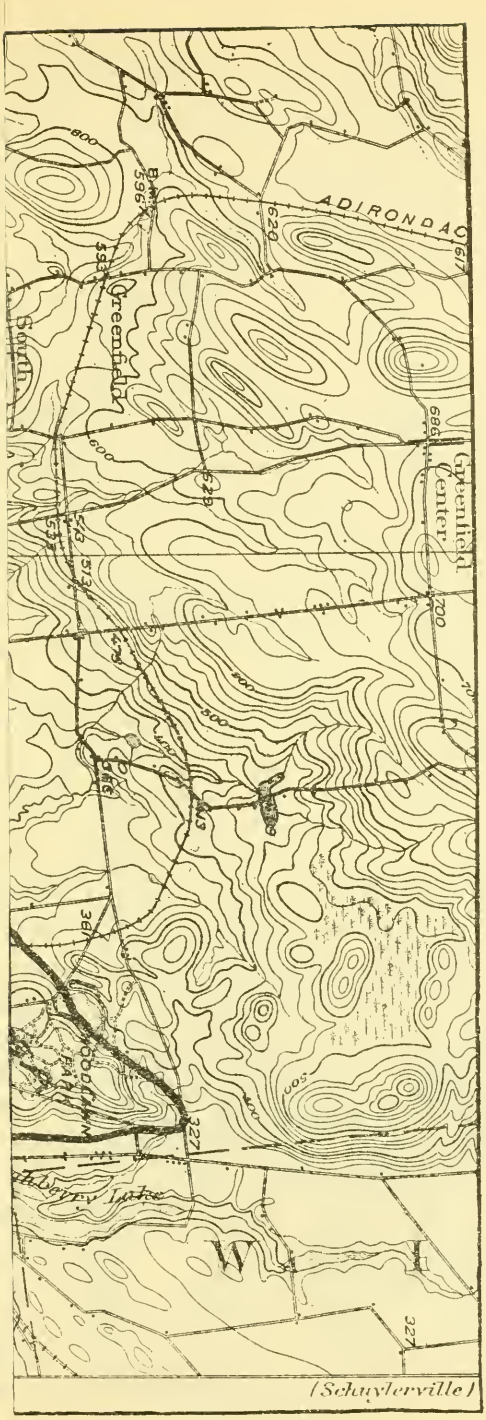
nowhere with higher lands, except on the north side, and that for a portion, only, of its northern boundary.

This elevated area, which we may call for convenience the Saratoga plateau, is properly connected by Doctor H. P. Cushing, of Cleveland, with a similar area lying to the north of it and separated from it by the northerly portion of the valley of the springs and the village brook; and the whole is described by Dr. Cushing as a "tremendous sand terrace" (New York State Museum Bulletin No. 169, page 14).

The Valley of the Springs. The natural springs which made Saratoga famous were all discovered in the valley of the village brook, which rises within the boundaries we have described and flows northeasterly, through a valley which it has eroded within the area embraced by these boundaries, from a point near the Congress Spring to the northern boundary of the plateau near the Red Spring. The course of this stream practically marks the southeastern edge of the hill or mountain we have mentioned, which might well be called the Saratoga mountain, and it is along this eastern edge that the geological fault is found through which, it has long been the opinion of many who have given attention to the subject, the mineral waters flow up from great depths where they have been thought to obtain their content of chlorides and carbon dioxide.

Depletion of Mineral Water Head in the Plateau. It was in the middle of the Saratoga plateau that the Lincoln Spring Company and the Natural Carbonic Gas Company built their plants and drilled artesian wells out of which they obtained the supplies of carbon dioxide which they required for the prosecution of their business.

In the early summer of 1911, the Commissioners of the State Reservation at Saratoga Springs acquired the property of the Natural Carbonic Gas Company for the Saratoga Reservation, but permitted the former owner to continue its operations upon the property until the 21st of October following, when the pumping of all its deep wells which penetrated the rock was stopped. Immediate observations of some of the wells in operation were then taken and it was found that the level of the mineral water in them was from 150 to 180 feet below the surface of the ground



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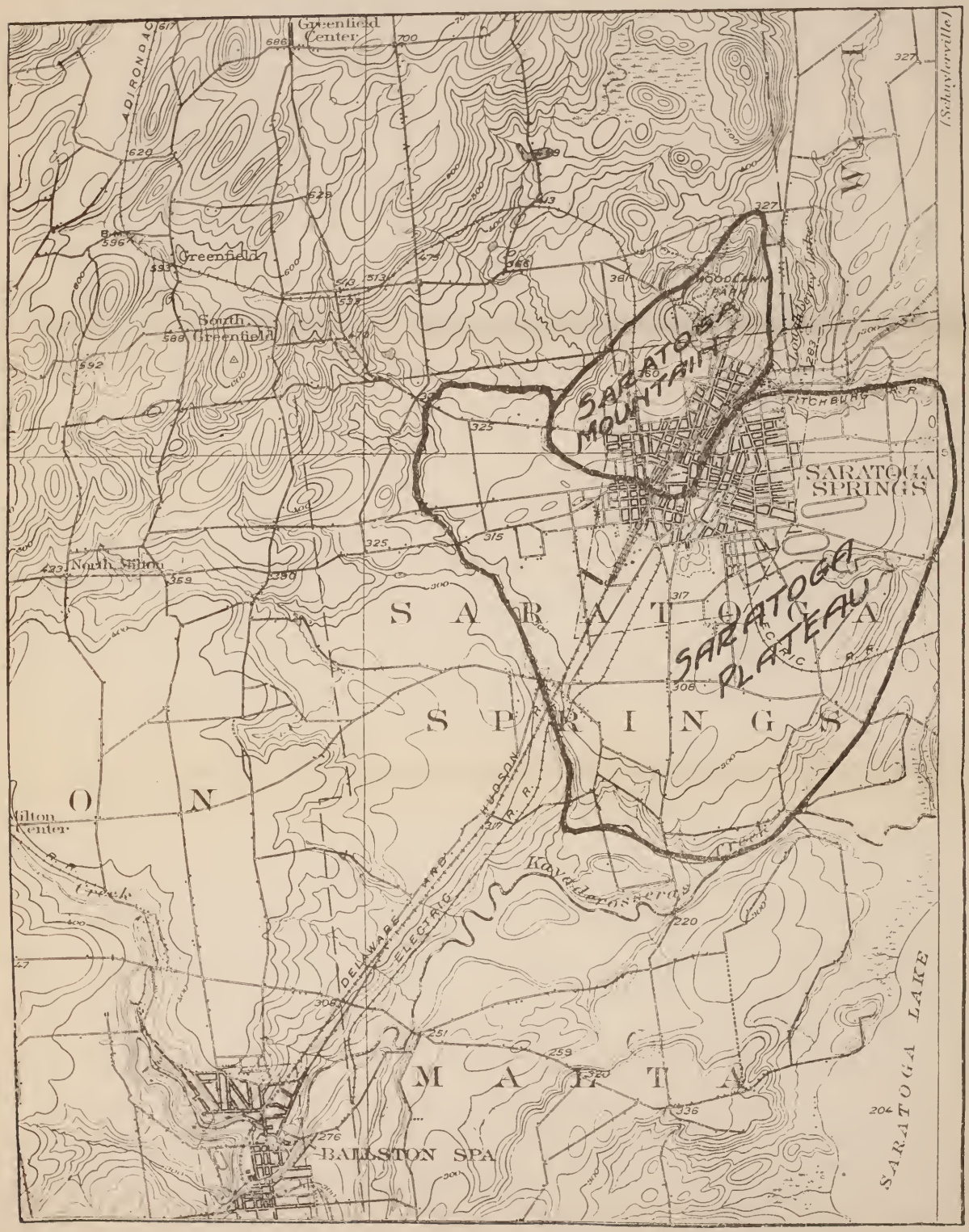
Greenfield Center
ADIRONDACKS
Greenfield
South Greenfield
North Milton
Milton Center
SARATOGA MOUNTAIN
SARATOGA SPRINGS
SARATOGA PLATEAU
SARATOGA
SPRINGS
ONTA
MALTA
BALLSTON SPA
SARATOGA LAKE
Kayaderosseras Creek
Mud Creek
Hudson R.
Delaware & Hud. Electric R.
Fitchburg R.R.
Woodlawn Park
(Schuylerville)

or at a point only about 150 feet above sea level. At the same time ground water was standing in driven wells contiguous to the premises of the Natural Carbonic Gas Company at only twelve or fifteen feet below the surface. The following day the mineral water levels in the well which showed the greatest depletion had risen to 120.4 feet below the surface.

On the 21st of October, when the pumping of the deep wells of the Natural Company was stopped, other wells, on neighboring properties, at a considerable distance, showed a depletion of the mineral water head to a point nearly 100 feet below the surface of the ground; and, when the pumping was stopped, the water in these wells, as well as in those upon the Natural Company's property, began at once to rise.

On the 6th of November, the pumping of four shallow wells which did not extend down to the rock was discontinued. In December, the water stood in various wells over a wide area at from 80 to 100 feet below the level of the ground; and thereafter the water continued to rise in them, but at a constantly decreasing rate, until, in October, 1913, two years after the pumping of the Natural Company was stopped, the mineral water head stood at 35 feet below the surface of the ground, or about 20 feet below the ground water levels in contiguous driven wells.

Double Hydraulic System in the Plateau. It is apparent, therefore, that the superficial system of fresh ground water and the deeper system of mineralized ground water are not intimately connected through the Saratoga plateau and do not sensibly re-act upon each other within short periods of time. This may easily be accounted for by the fact that at a depth of about fifty feet below the surface there is a heavy deposit of clay, quite impervious to water, which sustains the upper ground waters and prevents their readily passing down into the lower strata where the mineral waters are found, and also tends to confine the gas and mineral water in the lower strata and prevent their coming to the surface and mingling with the upper fresh ground waters. The upper ground waters are constantly running off into the water courses which bound the plateau on every side.

It appears, therefore, to be a well established proposition that the mineral waters within the area of the plateau may be de-

pleted by pumping them from artesian wells without sensibly affecting the upper ground water levels.

Double System in Coesa Valley. The double system of ground water receives further interesting illustration from the observed conditions in the Coesa Valley at the southwestern edge of the Saratoga plateau.

The Coesa creek has here eroded a valley through the drift and underlying shales, the bottom of which is some eighty feet below the surface of the plateau, or twice as deep as the valley of the springs adjoining the northeasterly part of the plateau. All along the easterly side of the Coesa Valley, fresh ground waters are flowing out from the deposits of drift, and numerous artesian wells have been sunk in the valley, penetrating the shale and the underlying dolomite to the depth of several hundred feet, where the strata carrying the corbonated waters are found.

The Coesa Valley was also the scene of operation of companies seeking the natural carbon dioxide for commercial purposes. The State acquired these wells on the 26th of June, 1911. At this time the pumping was being done by the General Carbonic Company, a corporation formed by the consolidation of two previously existing companies, and at the time of the acquisition of its properties it was actively prosecuting its business, was pumping carbonated waters from its wells and had reduced the level of the waters in its wells to from 150 to 170 feet below the surface, or to a point about 80 feet above the sea level. (Report of Commissioners of State Reservation for 1913, p. 14.) This compared with the depletion of the mineral water head at the Natural property to a point about 150 feet above sea level shows a much more serious depletion in the Coesa Valley. The mineral waters in the Coesa Valley are encountered under a pressure which is sufficient, quite independently of any effect produced by the carbonic acid gas which they hold in solution, to cause the wells to spout to a considerable height above the upper ground water levels in the valley. This pressure is sufficient to raise the mineral water in a stand-pipe to a height of thirty or forty feet above the level of Coesa creek at the Champion wells.

Artesian System. By opening these wells at the surface of the ground and permitting them to flow off freely, they will yield an

immense quantity of water and rapidly deplete the mineral water levels to the extreme northerly edge of the plateau and produce an effect clearly observable in the valley of the springs within twenty-four hours — thus illustrating still more clearly the existence of artesian conditions, i. e., a flow of ground waters induced by a remote head beneath impervious geological strata. These facts also negative the theory that the flow of mineral water from a given well is to be accounted for by the hydrostatic pressure of the ground water in immediate proximity to it and compel us to go to a distance to find the efficient head.

I am aware that very competent experts have in the past expressed the opinion that it was not necessary to go to a distance to find a head for the mineral water springs and wells (Hathorn v. Strong's Sanitarium, Sten. Min. p. 693); but this was at a time when the fact had not been demonstrated that the mineral water system was artesian and the normal engineer's ground water levels at the various wells had not become known. Dr. Henry M. Ami of Ottawa even then stated that the supply might come from a distance of scores of miles (Idem pp. 389, 396).

As might be expected, when wells in the Coesa Valley are opened and the water is permitted to flow freely from them, the effect observed bears a relation to the distance of the point of observation from the point of flow, the depletion of head at the Lincoln and Natural properties in the central part of the plateau being much greater than the depletion observable in the valley of the springs within the same limited period of time.

Progress toward normal from depletion. When the Commissioners of the State Reservation acquired the property lying in the Coesa Valley from the carbonic gas companies that had been operating there, the hydraulic conditions had been so far modified by such operation that it was impossible to know what the normal conditions were. Since then, however, the unnatural draft through the wells at that point by means of pumps and gas-lifts having been terminated and the wells so controlled that but a small quantity of water is delivered from them, the situation there has been gradually approximating that which existed before any of these wells were drilled and at a time when the springs in the valley of the springs at Saratoga were in their best estate; and,

since this unnatural draft was stopped, the springs in the village have also been slowly improving and returning to their former condition.

Progressive dilution as indicating direction of flow. In drilling the very large number of wells in the Saratoga mineral water tract that have produced saline carbonated water, this water has been encountered invariably in the strata of the magnesian limestone known as the Little Falls dolomite. It has been found flowing so freely in these strata that it has come into the wells at the rate of several gallons each minute, sometimes in quantities as great as fifteen gallons and in one or two cases at a much higher rate.

It has been the opinion of some geologists that the mineral waters obtain their carbon-dioxide and soluble chlorides first and, having thus by the presence of carbon-dioxide acquired the power to dissolve carbonates of calcium and magnesium, take up these carbonates from the magnesian limestone strata in which the waters usually have been found.*

The amount of carbon-dioxide in the waters flowing from the different wells, which is in a general way quite closely related to the chlorine content, is shown by many analyses, which disclose the fact that the saline and gaseous contents are greatest in the wells farthest south and quite constantly diminish as you go in a northerly direction. This appears from the following table in which the wells are stated in their order from southwest to northeast and the names of the springs or wells are given with the content of soluble chlorides in the waters of each expressed in parts per million:

	Parts per Million	Date of Analysis
Hathorn No. 2	11,749.89	April 30, 1913
Hathorn No. 3	10,000.51	Feb. 6, 1913
Adams (now Orenda)	5,928.81	May 14, 1913
Lincoln	6,282.51	April 26, 1896
Hathorn No. 1	3,567.60	May 28, 1913
Emperor	2,664.44	June 19, 1912
Old Red	382.27	Aug. 14, 1912

* Testimony of Prof. C. F. Chandler in Hathorn v. Strong's Sanitarium — Stenographer's Minutes, p. 289; John H. Clarke, Idem p. 923. L. C. Beck's report of the Mineralogy of New York State. New York State Museum Bulletin No. 159, p. 63.

The apparent failure of the Lincoln spring to conform to the general rule is probably due to the fact that the analysis of its waters employed in this comparison was made sixteen or seventeen years before the analyses of the other springs and before the depletion to which all the springs were subjected as to their mineral content as well as their hydraulic head by the pumping of the carbonic gas companies. An analysis made at the present time would probably place the Lincoln spring between the Adams and Hathorn No. 1.

This constant weakening of the waters as you proceed northerly from Hathorn No. 2, the southernmost, whose waters are the strongest of all in their chlorine content, suggests the probability that the movement of the waters is in that direction and that they become gradually weaker by the admixture of fresh ground waters the farther they traverse the strata of the dolomite.*

Increasing Alkaline Content as indicating direction of flow. If the waters move in this direction, it would be natural to expect, since they are not fully saturated with bi-carbonates of lime and magnesia,† that we should find the ratio of their content of these substances to their content of chlorine constantly increasing. Such expectation is fully realized by the facts, as is strikingly shown by the following table, in which the ratio, expressed in percentages of bi-carbonates of calcium and magnesium to total chlorides, is shown:

Hathorn No. 2	64.6 per cent.
Hathorn No. 3	64.9 per cent.
Adams (now Orenda)	81.2 per cent.
Lincoln	87.9 per cent.
Hathorn No. 1	115.7 per cent.
Emperor	117.8 per cent.
Old Red	291.2 per cent.

I have endeavored to illustrate this matter and make it obvious at a glance by superimposing upon a chart, showing the total chloride and total bi-carbonate contents of different wells between Hathorn No. 2 and the Red Springs, another chart, showing the ratio between these two classes of salts in the different waters.

* N. Y. State Museum Bulletin 159, p. 55.
† Idem, pp. 28, 57.

The black figures at the left indicate parts per million; the total chlorides are indicated by a dotted line, the total bi-carbonates are indicated by a black line and the superimposed diagram, exhibiting the ratio of bi-carbonates to chlorides, expressed in percentages, is drawn in a broken line.

The measureably regular rate of increase in bi-carbonates shown in the springs that have been named will be found not to obtain exactly in the case of every spring, some showing a greater or less departure from it, though not to a sufficient degree to impeach the general proposition; and the departures are doubtless due to the fact that the subterranean channels through which the waters flow are not like a direct and continuous pipe line but are more or less irregular, and that waters which come to the surface at points not distant from each other, may reach those points by routes quites different in point of distance traversed. Except for the very great and quite unusual content of those salts found in the waters of the Red springs, the same progressive increase of bi-carbonates continues to the Gurn spring, which lies seven miles in a northeasterly direction from the village of Saratoga Springs. Here we find a content of these salts equivalent to over 130 per cent. of the total chlorides.

The exceptional content of the Red springs is probably due to the fact that these springs are shallow ones and do not penetrate the rock strata nor encounter the principal mineral water courses, but get their supply by a slow process of percolation through the earth which overlies the rocks. The flow of these springs is very scanty, and the waters stand for a long time in contact with the limestone before they find their way to the surface.

Effect of flow at intermediate points as indicating direction of flow. The result of the experiment of opening the Champion wells and permitting them to flow is important as indicating the direction of the movement of the mineral waters in the dolomite strata. The wells to the north of the Champion wells were soon and greatly affected, but those to the south showed little effect. This might be expected if the waters are flowing northerly and the head that caused the flow is to the south. An orifice in a water pipe has a greater effect upon the pressure at points beyond it in the direction of flow than at points between it and the head.

So, too, withdrawing from a stream at any point a large part of its flow has little effect upon points above it on the stream. Its greatest effect is felt at points below.

At the period of the greatest depletion of the mineral waters from the pumping at the plants of the gas companies, when the springs in the village had all stopped and had apparently realized complete extinction, the Hathorn No. 2, the Coesa (then Carlsbad No. 2) and the Adams (now Orenda), all lying at or near the southern extremity of the mineral water belt, were flowing with apparently undiminished vigor. This could hardly have been possible if the depletion of the waters had taken place at a point in the mineral water channels above these springs.

The result reached by Mr. Charles G. Anthony, the consulting engineer of the Commissioners of the State Reservation, in his determination of the curve, formed by the intersection of the cone of depression at Lincoln park by a vertical plane running northerly and southerly, leads to the same conclusion. He found the curve to be flatter toward the north than toward the south, showing the former to be in the direction of the flow. This determination was reached by a computation based on data secured by measurements of the water levels in many wells on the Lincoln Spring and Natural Carbonic Acid Gas Companies' properties and in other wells in that neighborhood.

A careful consideration of the facts stated impels us to the opinion that the direction of the flow of the mineral waters in the strata of the dolomite is from southwest to northeast for the whole distance between Hathorn No. 2 and the old Red spring.

Carrying our computations based upon the increasing ratio of the bi-carbonates of the alkaline earths to total chlorides a step further, we may infer that the percentage of these bi-carbonates increase in their ratio to the chlorides at the following rates for the distances traversed by the waters in passing between the following points:

From	*To*	*Distance traversed*	*Distance for each increase of 1 per cent in ratio*
Hathorn No. 2	Adams (Orenda)	2,400 feet	144 feet
Hathorn No. 2	Lincoln	8,000 feet	343 feet
Hathorn No. 2	Hathorn No. 1.	13,600 feet	266 feet
Hathorn No. 2	Emperor	16,400 feet	308 feet

At Ballston, where there are two springs lying somewhat to the north of west and south of east and at a distance of 1,200 feet from each other, we find that the ratio of bi-carbonates of calcium and magnesium to chlorides is as follows: Artesian Lithia Spring: total chlorides, 12,496 parts per million; bi-carbonates of calcium and magesium, 6,640 parts per million; ratio of bi-carbonates to chlorides, 53.1 per cent. Hide-Franklin or Comstock spring: total chlorides, 11,925. parts per million; bi-carbonates of calcium and magnesium, 6,829 parts per million; ratio of bi-carbonates to chlorides, 57.2.

We also infer that the mineral water flows from the former to the latter and that the increase of the ratio of bi-carbonates to chlorides is at the rate of 292 feet for each 1% increase, a result quite comparable with that obtained by similar computations between Hathorn No. 2 and Hathorn No. 1.

No more uniform rate of gain could, it seems, be expected and these results enable us to reach some general conclusion relative to the place where it is probable the mineral waters enter the strata of dolomite.

Probable distance in dolomite strata traversed by waters. If carbonated waters flowing through dolomite strata will increase their content of bi-carbonates from 64.6 per cent of the chlorine content to 115.7 per cent in traversing the distance between Hathorn No. 2 and Hathorn No. 1, the point where the saline carbonated waters enter the dolomite strata and begin to dissolve out their content of calcium and magnesium carbonates from these rocks ought not, under like conditions, to be more than 3.25 miles southerly from Hathorn Spring No. 2.

If a similar computation should be based upon the increase of calcium and magnesium bi-carbonates between Hathorn No. 2 and the Emperor spring, it would indicate that this point is 3.77 miles from Hathorn Spring No. 2.

Applying the same method to the Ballston springs, we locate the point about 2.9 miles northwesterly from the Artesian Lithia spring at Ballston.

The point thus located will be found in a plateau described by Doctor H. P. Cushing of Cleveland in the New York State Museum Bulletin No. 169 at page 14 as a great sand terrace in

the town of Milton at a somewhat higher level than the Saratoga plateau and which is at least 100 feet above Hathorn No. 2 and still higher above the wells at Ballston. This plateau or sand terrace connects immediately with the foothills of the Kayaderosseras range and with a still more elevated region that might furnish a head for such an artesian system as we have been contemplating.

The maps accompanying New York State Museum Bulletin No. 169 by Doctors Cushing and Ruedemann show that west of and not far from this point there are faults through which waters holding carbon-dioxide in solution might come up from great depths and flow into the natural channels which the bedding planes of the Little Falls dolomite offer them and there begin the process of dissolving out of the rocks their constantly increasing content of bi-carbonates of calcium and magnesium.

Attention should be given to the fact that, after we enter the valley of the springs at Saratoga, a much more rapid rate of increase in the ratio between chlorides and bi-carbonates is realized. This may be due to the fact that, after the fault line is encountered, the mineral waters making their escape into and mingling with the upper system of ground waters through the opportunity which the fault affords, the rapidity of the northward flow is greatly retarded and much more time is required for the flow of waters from Hathorn No. 1 to the Red spring than for any equal distance between Hathorn No. 1 and Hathorn No. 2.

The absence of influences that seem to have retarded the rate of flow north of Hathorn Spring No. 1 would seem to indicate the possibility of a more rapid flow south of Hathorn No. 2 and west of the Artesian Lithia spring in Ballston, before any waters have been tapped off by wells and springs and the head thereby reduced, and would also indicate a correspondingly greater distance traversed by the waters during the period of exposure to the dolomite strata requisite for the dissolving out the 64.6 per cent. of bi-carbonates of calcium and magnesium in Hathorn No. 2 and the 53.1 per cent. in the Artesian Lithia spring. This would tend to move farther to the west the probable point where the saline carbonated waters enter the limestone and locate it nearer to the Rock City or East Galway faults shown on the map of Doctors Cushing and Ruedemann.

Indication of chemical content of Ballston wells. The analyses of the Artesian Lithia and the Comstock mineral springs at Ballston, show that the ratio of bi-carbonates to chlorides does not continue to decrease from north to south between Hathorn No. 2 and the latter wells according to the rule that applies to the wells north of Hathorn No. 2. If the rule had held good, the water at Ballston would have been found devoid of carbonates and possessing a carbon-dioxid and chlorine content only. We have seen, however, that the Ballston waters contain carbonates in a ratio slightly less than those of Hathorn No. 2.

Contrary opinions as to direction of flow. This theory as to the movement of the carbonated waters in the dolomite strata is at variance with some of the opinions that have been expressed by scientific experts.

In the case of Hathorn v. Dr. Strong's Saratoga Springs Sanitarium, the trial of which was begun in 1905 and concluded in 1907, experts for the plaintiff testified that, in their opinion, the waters of the Hathorn spring came to it from the east. The experts may have been influenced by facts that seemed to indicate an effect upon the plaintiff's well by the defendant's operations, and, perhaps, insensibly, by the stress of their case, which demanded such a conclusion.

Prof. James F. Kemp of New York in the New York State Education Department Bulletin 517, published April 15, 1912, states that:

> "William R. Hill, C. E., by a careful series of levelings upon the waters standing in the wells of the Natural Carbonic Gas and Lincoln Spring Companies at a time when no pumping was done and the waters had resumed their normal positions, and by determining the resultant of his observations, reached the conclusion that the natural flow was in a direction south 65 east, or 25 degrees south of east."

Professor Kemp then adds: "While these expressions must be taken as general, they undoubtedly express the truth."

It is sufficient to say of these statements that no such time was ever reached as that mentioned by Mr. Hill, when no pumping was being done and the waters had resumed their normal position, after the companies he names had begun their operations and prior

to the date of Professor Kemp's publication. The pumping was not all stopped upon the properties of these companies until two days before such publication and now, at the end of three years from that date, the waters have probably not reached their normal position.

Most of the pumping was indeed stopped in October, 1911, and the waters began to rise from that time. During the first year there was a general rise of more than 100 feet in these wells and, during the second year, a rise of an additional twelve to fifteen feet. It is believed that the water levels are still below their normal.

Moreover, it has been demonstrated that the present water levels in the wells can be depleted to the extent of nine or ten feet in twenty-four hours by simply opening wells in the Coesa Valley and permitting them to run off.

Under such circumstances, any deductions from observed mineral water levels at the Natural and Lincoln properties before the operations of these companies were concluded and while the draft upon the mineral water supply was unchecked in the Coesa Valley, can be of little value, as the waters were never normal but always depleted by artificial causes, which were themselves constantly changing.

The reasons heretofore urged in support of different theories as to the direction of the movement of the mineral waters in the dolomite seem inadequate and not at all as cogent as those which I have adduced above in support of my conclusion that the direction of flow is from southwest to northeast.

Origin of the sodium bi-carbonate content. Prof. Kemp expresses the opinion, in New York State Museum Bulletin No. 159, at pages 63 and 64, that the source of the sodium bi-carbonate is deep seated. If such were the fact, the waters would already have acquired their supply of this substance when they entered the dolomite strata. We should then find a decrease from dilution in the sodium bi-carbonate corresponding with that of the chloride of sodium as we proceed in a northerly direction. There does not seem to be any such correspondence, as will be seen by the accompanying graph which shows the total chlorides content, the sodium bi-carbonate content and the ratio between them in

the same manner employed for the content of bi-carbonates of calcium and magnesium.

Nor is there the same regularity in the increase of sodium bi-carbonate in proportion to the chlorine content which we observe in the case of the bi-carbonates of calcium and magnesium. In view of the fact that sodium carbonate is not one of the ingredients of the dolomite, we should hardly expect it. The very great fluctuation in the relative amount of this substance found in the waters seems to indicate the effect of local and varying conditions as affecting the supply. As local deposits of this substance or irruptions of waters heavily charged with it do not seem probable, we are rather forced toward the conclusion that it results from secondary re-actions which Prof. Kemp deems not improbable. (N. Y. State Museum Bulletin No. 159, p. 61.)

I venture the query whether the cause may be found in the inflow of superficial waters carrying a content of H_2SO_4 which they may have acquired from the pyrites that abounds in the shale that overlies the dolomite in which the mineral waters are usually found. The proportion of sodium bi-carbonate seems to be unusually high in the Geyser and Hathorn No. 1 springs. These springs were depleted to the point of temporary extinction by the pumping, and the presence of H_2S was one of the principal results observed from such depletion. It also resulted, in the case of each of these springs, in an increased proportion of sodium bi-carbonate, to a degree that practically changed the character of the water of the Geyser Spring. The latter effect is strikingly shown by comparing the relative quantity of sodium bi-carbonate now in the waters of these two springs with the quantities of that substance which they carried before such depletion began and when the earlier, normal conditions had not yet been disturbed.

It will be seen, upon examining the charts, that there is no such correspondence between the sodium bi-carbonate and the chlorides as was shown to exist between the quantities of chlorides and total carbonates. It is difficult to detect any relation at all between them. The quantity of sodium bi-carbonate does not appear, therefore, to depend upon the degree of dilution, nor the length of time the waters have been exposed to the action of the dolomite strata, but to be determined by some other factor, perhaps by that which I have suggested above.

A return of these waters to their original character may be realized with the restoration of original hydraulic conditions.*

These circumstances, though not sufficient, perhaps, to found a theory, may be helpful as pointing in the direction of a possible explanation. It should be stated in this connection, however, that if we should assume sulphuric acid to be the re-agent giving rise to sodium bicarbonate, we should expect to discover sulphates produced by the same chemical changes. We find, in fact, however, so small a quantity of sulphates as not to confirm such expectation.

Mineral waters flow in subterranean streams. The waters precipitated upon the surface of the ground in the form of rain or snow either pass back into the atmosphere by evaporation, or run off in the superficial water courses, or sink into the ground. The waters that enter the ground for the most part percolate downward and laterally and finally run off in springs and unite with the waters of streams discharging into the ocean. Through the soil and deposits of sand and gravel they move slowly, without definite channels; but, when they reach the consolidated strata we call rock, they often, especially in a limestone country, collect in the natural and convenient channels afforded by the bedding planes, or in channels eroded by the waters themselves, and flow

* A recent analysis of the water of the Geyser spring, made since the foregoing paragraph was written, upon comparison with earlier analysis shows that the possibility embodied in the foregoing suggestion is being realized. An analysis of water taken from that spring on the 3rd day of July, 1912, showed:

Total chlorides 2254.07 milligrams per liter.

Sodium bicarbonate 2238.22 milligrams per liter.

An analysis of water taken from the same spring on the 14th day of December, 1914, showed:

Total chlorides, 2432.25 milligrams per liter.

Sodium bicarbonate, 1607.15 milligrams per liter.

This shows in a period of 2 years, 5 months, 11 days, an increase in chlorides of 178.18 milligrams per liter, a decrease of sodium bicarbonate of 631.07 milligrams per liter.

This falling off in the sodium bicarbonate content of the Geyser water during the period mentioned is greater than the entire content of that substance in thirteen out of twenty springs whose waters have been analyzed by the State Department of Health since the Saratoga Reservation was established.

An analysis of the waters of the Minnonebe spring, taken December 14, 1914, gives similar results, though the increase in chlorides is greater and the loss of bicarbonate of sodium is less. It also shows a rapid approximation of Minnonebe water toward Geyser water since the last previous analysis. The two springs are near each other, the relations between them appear to be very intimate and their waters are now practically the same in their mineral contents.

in subterranean streams or water courses. Such streams are often encountered in natural caves, as in Howe's cave in Schoharie county and the Mammoth cave in Kentucky.

Percolating waters no doubt pass by insensible gradations into subterranean streams, but a distinction has been made between the former and waters flowing in subterranean water courses; and different rules of law have been established for the regulation of the rights in the two classes of waters of the owners of the lands through which they pass.

The movement of percolating waters is relatively slow, ordinarily not more than 5 or 10 feet each day; and, when a large quantity of ground water is sought to be obtained from such a source, some device for its collection is necessary, such as horizontal galleries, or a system of many driven wells. In the case of the carbonated waters of Saratoga, however, when the water bearing strata are pierced, a copious flow at once appears—sometimes a very large flow, as in the wells known as Champion Nos. 2 and 3, which will discharge water at the rate of over 100 gallons per minute. It is inconceivable that a single well only six inches in diameter would produce such a flow of percolating waters; it could only be obtained from a subterranean stream.

The subject is capable of further and striking illustration by a comparison of the relative effect of pumping the deep wells which penetrate the rock and the shallow wells, which terminate in a deposit of coarse gravel overlying the rock, in which, as we shall see, mineral waters are percolating, at the property of the Natural Carbonic Acid Gas Company in the Saratoga plateau, between the months of July and November, 1911.

During this period shallow and deep wells of the Natural Company were pumped for the same period of time, at the same rate and by precisely the same devices. From 3 to 5 pumps were operating in shallow wells, and from 11 to 17 in deep wells; the average number of shallow wells pumped during the entire period being 3.66, and the average number of deep wells, 14.1. The shallow wells yielded on an average 3.2 gallons per minute and the deep wells 14.1 gallons per minute, or nearly five times as much.

About the same time, two wells that were being pumped on

the Lohnas tract, not far away, produced, one of them only 1.665 gallons per minute, and the other 0.868 gallons per minute, much less than the average amount produced by the shallow wells on the Natural Company's property.

If the mineral waters had been encountered in a more compact and finer grained deposit than the coarse gravel in which they were found, the amount yielded by the shallow wells would have been much less than that which was in fact produced.

These results emphasize the opinion already expressed that the quantities realized from the flow of many deep wells and pumps operated in others have been greatly in excess of what could have been obtained from a supply of percolating waters.

Another reason for concluding that the mineral waters in the dolomite exist as streams rather than as percolating waters is the fact of the great rapidity with which a depletion at a given point is communicated to another point at a distance. By opening up the Champion wells, whose very large flow has already been mentioned, an effect can be produced within a few hours at the Natural and Lincoln properties more than a mile away, and the mineral water head there depleted to the extent of several feet in such a period of time. Such a prompt effect could not be observed at so great a distance in a system of percolating waters whose maximum rate of movement would not exceed a few feet in a day.

As superficial water courses frequently overflow shallow areas along their margins and form swamps or marshes that extend to considerable distances from the channel, so it is quite conceivable that the subterranean stream may flow off laterally in the bedding planes or into other openings to a distance from its channel. The fact that wells at a considerable distance from the line of the main channel of the mineral waters, which is indicated by the freely flowing wells and is practically a straight line from the Red Spring to Hathorn No. 2, seem to have a restricted flow or quickly fail, as in the case of the old Carlsbad, the new Shonts, the Strong well and others, would seem to indicate some such subterranean conditions.

Equally demanding consideration is the escape from the rocks underlying the Saratoga plateau of the mineral waters flowing in the dolomite strata and their percolation through the deposit

of gravel above the rock and below the impervious strata of clay. The connection between the mineral waters in the dolomite and those in the gravel are close and an overdraft in either may deplete the other. For two years, a depletion in the gravel has been in process of restoration, and normal conditions will not be fully reached until such restoration is complete. The hydrostatic pressure of these percolating waters will then prevent further outflow from the rocks and the head in the valley of the springs will reach the normal, provided no other disturbing factors are introduced.

In this connection it is worthy of note that, if a line be drawn from the Old Red Spring to Hathorn No. 2, a distance of three or four miles, it would be found to pass very near to the many natural springs and artesian wells that produce or have at any time produced mineral waters. This same line, prolonged in either direction, would connect the springs at Ballston with Gurn spring, nearly or quite 15 miles distant from each other. This is more suggestive of a subterranean stream or water course than of a body of water diffused over a large area.

Contrary opinions. In the case of Hathorn v. Strong's Saratoga Springs Sanitarium, reported in 55 Misc. 445, the court in its opinion said, at page 447, "Without discussion, it may be premised that none of the waters of Saratoga belong to this class," i. e., the class of flowing waters. This premise seems to have been too hastily assumed and without adequate consideration. At least, the facts now known point to a different conclusion.

In the case of Hathorn v. Strong's Sanitarium, to which reference has been made, much time was consumed in the consideration of the character of the rocks underlying the mineral water zone of Saratoga. The geological experts agreed that the bedding planes of the limestone formations were natural waterways and natural channels for water and cited instances of the existence of water courses of great extent in such formations in other places, but expressed the opinion that such a flow of mineral waters in the strata of the magnesian limestone at Saratoga, notwithstanding the remarkable power of waters holding CO_2 in solution to enlarge the openings in joints and bedding planes by dissolving the rocks through which they pass, was not probable.

They assigned, however, no substantial reason as a basis for such opinion, in spite of the recognized existence of conditions likely to give rise to such water courses; and their attention was not directed by counsel to the facts we have mentioned, which seem to indicate the existence of such water courses. (See Stenographer's Minutes, Testimony of Prof. Chandler, pp. 312, 322; F. H. K. Merrill, pp. 345, 347, 351; Henry M. Ami pp. 351, 371, 379, 391, 408, 427; Rudolph Hering, p. 668; John H. Clarke, p. 935; David H. Newland, p. 1113.)

Prof. James F. Kemp, when examined as an expert on behalf of the defendant in the case of the People v. The N. Y. Carbonic Acid Gas Co., testified on cross-examination, in response to my interrogatories, that the bedding planes of rock formations very often offer a convenient passage for subterranean waters and that it is common for waters to flow along such passages for a considerable distance and that, except that the bedding planes are not particularly abundant or pronounced in the Beekmantown rock in and about Saratoga, he knew of nothing that would be likely to offer a barrier to the flow of waters through them. (S. M., p. 380.)

Office of the Fault. Kemp's Bul. p. 51. The fault, which has been an object of great interest to so many scientific men and has been generally supposed to be the natural pathway of waters emerging from great depths freighted with their content of carbon-dioxide and sodium chloride, or the laboratory in which carbon-dioxide was produced by chemical reaction,* it is probable does not perform so important an office as has been generally supposed. If the foregoing suggestions are well founded, the fault merely affords an outlet to the waters from the dolomite strata in which they have been flowing for a long distance. As these strata have here practically reached their northern limit and die out here upon the Laurentian beach, the waters would probably reach the surface near the same place without the help of any rending of the strata by natural convulsions such as the fault suggests.

* Testimony of Prof. Chandler in Hathorn v. Strong's Sanitarium, Stenographer's Minutes, p. 289; testimony of Dr. John H. Clarke, Idem, pp. 922, 946; testimony of Prof. Kemp in People v. N. Y. C. A. Gas Co., Stenographer's Minutes, pp. 354, etc.

In this connection, attention should be given to the fact that the temperatures of the waters, so near to the mean annual temperature at the surface, indicates that the waters have not come through the fault directly from great depths; for, if such were the case, they would possess thermal characteristics that are lacking. The temperature of the waters, wherever encountered, is nearly uniform, showing that they have been moving in strata not near enough to the surface to be affected by the seasonal variactions of temperature, nor deep enough to acquire a much greater degree of heat than the mean annual temperature.*

For these reasons, it seems probable that the waters merely make their escape from the dolomite strata at the well known fault line, after flowing through those strata for a distance of miles from the place where they emerge from greater depths.

Desirability of temperature observations. A careful series of observations of the temperatures of the waters for a considerable period of time would throw additional light upon the subject. It is not improbable that they might show variations of temperature in the weaker waters at the northerly part of the mineral water tract, that would tend to establish the theory of progressive dilution from surface waters, by exhibiting higher temperatures in summer and lower in winter.

Interaction between two systems in valley of springs. The mineral waters in the valley of the springs flowed to the surface at or about the fresh ground water levels. Congress Spring was discovered in the channel of the village brook and lost for a time beneath its waters. It was found again only after the stream had been diverted and an excavation eight feet in depth had been made. The waters of the Pavilion spring were found boiling up in a swamp and were secured only by the construction of a coffer dam to hold back the surface waters, while an artificial channel was constructed through which the mineral waters might reach the surface without mingling with the fresh water. Similar conditions were found at most of the other springs.

It would seem probable, under such circumstances, since the mineral water head is so little different from that of the fresh

* Testimony of Prof. Kemp in People v. N. Y. C. A. Gas Co., Stenographer's Minutes, p. 301; N. Y. State Museum Bulletin No. 159, p. 41.

water that at times of high water, when the ordinary ground water has been raised by heavy rains or melting snow, it might, by its superior hydrostatic pressure, stop the movement of the mineral water from the orifices out of which it flows to the surface and even reverse the current in some channels and cause a flow of fresh waters into the channels usually occupied by mineral waters, thus effecting a dilution of the latter. Again, when the superficial or fresh ground water head was abnormally low, the more constant mineral water head would be relatively more vigorous and force out from and replace the fresh waters in the cavities into which they had flowed when the conditions were reversed; and the mineral waters would flow out upon the surface in a less diluted condition. Such an effect seems to be indicated by the results of analyses of the waters of springs taken at times of high ground waters in the spring and fall and again during periods of dry weather when the ground waters were low.

More exact knowledge of the conditions that may lead to such action and re-action between the fresh water and mineral water heads will soon be obtained from a series of observations that are to be made at my suggestion in the High Rock park, where circumstances are favorable to the undertaking. The High Rock pit gives an unusual opportunity to obtain an accurate knowledge of the variations in the mineral water head, while the level of the adjacent fresh ground waters can easily be measured here. By a careful series of measurements here, where the heads of the two systems approximate closely to each other, it may be found that each at times rises above the other and that this alternating superiority gives rise to the process of dilution and recovery which I have described.

And at this point attention should be called to the conditions in the Saratoga plateau and in the Coesa valley as indicating the actual or possible interactions there between the superficial ground waters and the artesian mineral water system.

In the plateau, the head of the mineral waters flowing and percolating through the rocks and gravel below the impervious clay strata having been enormously depleted by the pumping and being still below the levels of the upper fresh ground waters, there must be, to the extent to which there is communication be-

tween the two systems through the clay, a continual dilution of the former. This may be increased by the artificial openings in the clay made by the multitude of drilled wells. This may account, at least in part, for the present low mineralization of Hathorn No. 1 and other springs in the Saratoga valley. It is being gradually reduced by the rising mineral water levels in the plateau and would be stopped entirely if the mineral water head should rise above that of the fresh waters.

In the Coesa valley, however, an opposite effect is produced whenever communication is opened between the artesian mineral water system and the superficial ground waters. At that point, the head of the artesian system is, as has been stated, 30 or 40 feet higher than that of the fresh ground waters. Whenever the former is punctured, the mineral waters rush out of it with great force and mingle with the fresh surface waters and flow off in the adjacent water courses. The effect of this is to rapidly deplete the mineral water head, and such effect is communicated with great rapidity in the direction of the valley of the springs at Saratoga.

In consequence of these conditions, the normal relations of the heads of the two systems are continually liable to disturbance; and, whenever the mineral water head falls below that of the adjacent fresh ground waters, the latter tend to flow into the channels of the mineral water system and to dilute the former and to carry in any substances which the latter hold in solution. In this way, no doubt, waters holding in solution sulphureted hydrogen find their way into the mineral water wells at times and impair them.

Agency of CO_2 in raising the mineral waters. Kemp's Bul. p. 40. The mineral water head, as we proceed northeasterly from Hathorn No. 2, falls off at a very gradual and uniform rate, while the superficial ground water levels fluctuate greatly with the contour of the surface. The superficial ground water level is probably higher at Hathorn No. 2 than the mineral water head and continues so until the Adams spring is reached, when the former falls far below the latter and so continues across the Coesa valley. Then it rises once more above the mineral

water head and so continues across the Saratoga plateau, falling again when we enter the valley of the springs; until at Hathorn No. 1 the mineral water head is sufficiently above the fresh water head, except during flood conditions, to allow the mineral water to flow out freely and run off into the adjacent water course.

Under the circumstances, it is evident that, for much of this distance, the mineral water would never make its appearance at the surface unless brought up by a pump or by some agency other than mere hydrostatic pressure.* This agency is found in the carbon dioxide dissolved in the water, of which there is always enough to supersaturate the water at the normal atmospheric pressure. Prof. Kemp has estimated the amount at 5.4 volumes at the atmospheric pressure in the most strongly carbonated waters he found in any of a number of wells he examined.† This would all be held in solution in water subjected to the hydrostatic pressure due to a column of water about 150 feet in height in addition to the atmospheric pressure. The waters standing at that distance below the water level in all wells would be subjected to such a pressure, and all the gas the waters contained would therefore be in complete solution below that depth.

As carbonated waters rise in such a well, after reaching that point they begin to give up the gas held in solution in the form of minute bubbles, which constantly increase in size and number until the top of the well is reached, when the water appears frothing, and the gas rapidly passes off into the atmosphere.

In this frothy or foaming condition the specific gravity of the water is much below that of water in its normal condition and below that which it has in the lower part of the well, and the result is to enable the hydrostatic pressure under which water seeks to enter the well to support a column of such foaming water much higher than a column of water unmixed with gas and high enough to flow out upon the ground. This may be illustrated by the following simple diagram.

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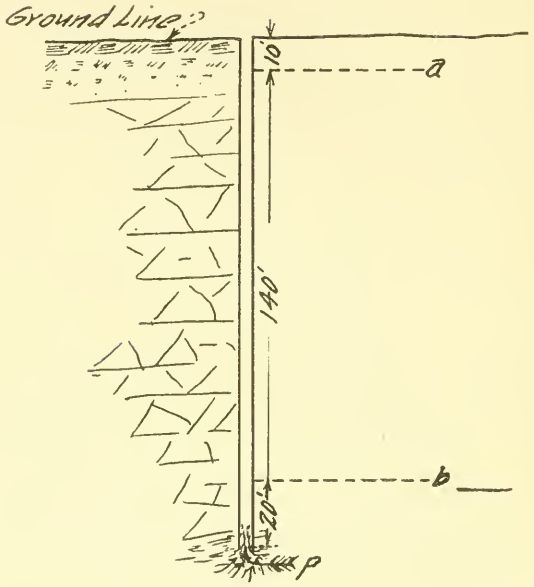
* Testimony of Henry M. Ami, Hathorn v. Strong's Sanitarium, Stenographer's Minutes, p. 436. Testimony of Prof. Kemp in People v. N. Y. C. A. Gas Co., Stenographer's Minutes, p. 278.

† Testimony of Prof. Kemp in People v. N. Y. C. A. Gas Co., Stenographer's Minutes, p. 210; also N. Y. State Museum Bulletin No. 159, p. 40.



This figure represents a well 170 feet in depth, into the bottom of which the water flows under a pressure (p) of 70 pounds to the inch. This head will, under ordinary conditions, support a column of water in the well approximately 160 feet in height. Under these conditions the water will stand at the level (a). But if the water contain 5 volumes of CO_2, it will approximately at the point (b) begin to give up its CO_2 with the result that its specific gravity will grow less and less above the level (b) as it ascends the well. Assuming that the mean specific gravity of the frothy water is only one-half as great as the water below the point (b), or the plane of saturation, the pressure (p) will then sustain a column of the lighter water twice as high as the distance between (a) and (b), or extending 130 feet above the mouth of the well. In other words, it will eject the water from the mouth of the well with a force equivalent to a pressure of about 30 pounds to the square inch at that point — sufficient to throw it high into the air.

This principle was correctly stated by Prof. Chandler in his testimony in Hathorn v. Strong's Sanitarium (Stenographer's Minutes, p. 320), and afterwards explained more in detail by Rudolph Hering, C. E., in the same case. (Idem. pp. 663, 699.)

It should be observed in this connection that the "buoyancy" which Dr. Ami said was imparted to the waters by the gas only occurs above the plane of saturation where the gas begins to come out of solution; below that the gas probably increases the specific gravity of the water, already greater than that of fresh water by reason of its content of soluble salts. (See testimony of H. M. Ami, Hathorn v. Strong's Sanitarium, Sten. Min. p. 541. Testimony of Prof. Kemp, People v. N. Y. C. A. Gas Co., Sten. Min. p. 372.)

The principle has been applied in what is known as the Pohle air lift, a device to raise water from a well by pumping air into it at a point considerably below the surface of the water, which accomplishes the same result as that produced by the CO_2 in many of the mineral water wells at Saratoga, whose waters would otherwise remain below the surface and would call for the aid of a pump to raise them.

This has given rise to the notion that the waters are, in their natural condition in the rocks, confined under a great pressure, exerted by the carbon-dioxide, in the same manner as carbonated water in a siphon, and that they are ready to fly out in an instant wherever a vent is given.* This is a misconception as to the actual conditions. It is true that the gas is frequently confined in the earth under pressure, but the pressure is caused by and can be nowhere greater than the hydrostatic pressure, which, as has been stated, is generally insufficient to raise the water to the surface of the ground, except when it is possible for us to get down to a much lower level than the general level of the surface, of which the Coesa Valley is an interesting illustration, the mineral water head there coming up in the wells through the superficial ground water system and towering 30 or 40 feet above it. At this point the mineral waters have no need of the aid of the natural gas lift to reach the surface, the hydrostatic pressure being ample to cause the wells to spout. Some of the wells are, however, made to flow more vigorously than they otherwise would do in consequence of the decrease of the specific gravity of the waters flowing from them for a considerable distance below the surface of the ground.

* Testimony of Prof. Chandler, Hathorn v. Strong's Sanitarium, Stenographer's Minutes, p. 312; Frederick H. K. Merrill, Idem, pp. 347, 384.

Sealing off flowing wells. In close connection with the subject of the office performed by carbon-dioxide in causing the flow of mineral water from wells is the phenomenon which is generally spoken of as the sealing off of wells. If the flow of mingled water and gas from a well under the influence of the gas lift be checked for a few moments by placing a cap on the top of the well tube, or even by holding the hand upon it when the pressure is not too great, the gas bubbles will separate from the water and, rising to the top of the well, will pass off into the atmosphere; and water unmingled with gas will remain in the well. The specific gravity of this water, being much greater, a water column of less height than the top of the well tube often suffices to hold back the carbonated waters seeking to enter the bottom of the well, and an equilibrium is established. The flow of the well is thus stopped for the time, and the well is said to be sealed off. Its flow will not be resumed until the water standing in it is pumped out, so as to admit carbonated water at the bottom and bring it to a point above the plane of saturation, where the gas coming out of solution may lighten the mass and enable the hydrostatic pressure to raise it above the mouth of the well. The well will then flow again and continue to do so as long as it is adequately supplied with sufficiently carbonated water, or until the process of sealing off is repeated.

Efficiency of the gas lift. In wells operating naturally by the gas lift, a gas pressure has been frequently recorded at the surface of the ground, and it is evident that such pressure varies with the amount of gas in the waters. The more highly carbonated the waters are, i. e., the greater the amount of gas they hold in solution when they enter the bottom of the well, the greater pressure will be developed at the surface when this natural gas lift is in operation.

For the purpose of computing the efficiency of the gas lift and the pressure at the surface due to different amounts of gas in solution, let us designate the number of volumes of gas at atmospheric pressure dissolved in the waters by " N ":

And the distance from the hydraulic level of the well to the plane of saturation by " H ":

$\frac{N-1}{2}$ will then represent the mean or average number of volumes of free gas in the well above the plane of saturation to each volume of water.

If the water below the plane of saturation contains three volumes, then the mean number of volumes of free gas above the plane of saturation will be $\frac{3-1}{2}$ or one volume of free gas for each volume of water through the whole distance "H".

If the water contain four volumes of gas, we have $\frac{4-1}{2} = 1\frac{1}{2}$ volumes of free gas for each volume of water through the distance "H".

Assuming now, for convenience of calculation, that a column of water 33⅓ feet in height exerts a pressure of 15 pounds to the square inch, and that this is the equivalent of the atmospheric pressure, we obtain the following results:

In the first case, where the water contains 3 volumes of gas, the plane of saturation will be 66⅔ feet below the hydraulic level. Disregarding the weight of the gas, we shall have the weight of the mingled column of gas and water above the plane of saturation equal to one-half that of a column of water alone, thus giving at the hydraulic level the hydrostatic pressure due to its elevation above the plane of saturation (66⅔ feet) less the weight of the gas and water column (equivalent to a column of water alone of 33⅓ feet); i. e., 66⅔ feet — 33⅓ feet = 33⅓ feet = 15 pounds.

In the same way, when there are 4 volumes of gas, "H" will be equal to 100. The average weight of the column of gas and water for that distance will be equal to 2/5 of a water column and the resultant head at the hydraulic level will be 100 — 40=60 feet = 27 pounds.

From the foregoing we may derive a formula for calculating the resultant head at the hydraulic level of the well from the operation of the gas lift due to different quantities of gas in solution in the water flowing from the well, and find it to be $\frac{N-1}{N+1} \times H$. From this we compute the following table:

Table showing resultant head and pressure at hydrostatic level due to different quantities of CO_2 in solution.

Volumes of CO_2	Resultant Head in feet.	Equivalent pressure in pounds to square inch
1	0	0
2	11.11	5
3	33.33	15
4	60	27
5	88.8	40
6	119	53.5
7	150	67.5
8	181	81.7

Relation of volume of gas to volume of water. Since the volume of gas under varying pressures is inversely proportional to the pressure, where N = 8, the gas volume as compared with the water volume at different depths in the well will be as follows:

At	a	depth	of	$233\frac{1}{3}$	ft.	0
"	"	"	"	200	ft.	$\frac{1}{8-1} = \frac{1}{7} = \frac{1}{7}$
"	"	"	"	$166\frac{2}{3}$	ft.	$\frac{2}{8-2} = \frac{2}{6} = \frac{1}{3}$
"	"	"	"	$133\frac{1}{3}$	ft.	$\frac{3}{8-3} = \frac{3}{6} = \frac{3}{5}$
"	"	"	"	100	ft.	$\frac{4}{8-4} = \frac{4}{4} = 1$
"	"	"	"	$66\frac{2}{3}$	ft.	$\frac{5}{8-5} = \frac{5}{3} = 1\frac{2}{3}$
"	"	"	"	$33\frac{1}{3}$	ft.	$\frac{6}{8-6} = \frac{6}{2} = 3$
"	"	"	"	0	ft.	$\frac{7}{8-7} = \frac{7}{1} = 7$

We may, from this investigation, derive a general formula for ascertaining the volume of free gas resulting from a solution containing a given number of volumes of gas at any pressure, as follows:

Let N equal the number of volumes of gas to each volume of water.

Let x equal the number of volumes of free gas to each volume of water under a given pressure.

Let y equal any pressure expressed in atmospheres.

We shall then have:

$$x = \frac{N - y}{y}$$

For example, where N = 8, at a pressure of 7 atmospheres, we shall have:

$$x = \frac{8 - 7}{7} = \frac{1}{7}$$

Under a pressure of half an atmosphere, the gas volume will be 15 and under a pressure of 1/4 of an atmosphere, 31, constantly progressing toward infinity as the pressure approaches zero, at which point it will reach infinity.

In like manner, to determine the pressure when the number of volumes of free gas to each volume of water is known, we have:

$$y = \frac{N}{x+1}$$

Thus, where $N = 8$ and there are 3 volumes of gas to each volume of water, we have, $y = \frac{8}{3+1} = 2$, the pressure expressed in atmospheres.

Graphic representation of increase in gas volume. If we plot this progressive increase of gas in a graph, we shall find that it does not proceed in a straight line but on a curve. This curve represents the effect of Boyles' law.

The following graph will illustrate the proposition. OX and OY may be taken as rectangular co-ordinate axes. The abscissa of any point in the curve may be designated by x and the ordinate by y. The foregoing formulae and computations will then be applicable and all problems involving the relations of pressures and volumes may be solved by the application of familiar mathematical principles.*

Relation of volume of water to each volume of mingled gas and water. If now we turn our attention to the water volume and consider its relation to the volume of mingled gas and water, we shall obtain the following results where N = 8.

At the depth of 233 1/3 feet below the water level the gas will all be in solution and the entire volume will be water which may be stated at..... 8/8

At the depth of 200 feet we shall have for each volume of water 1/7 of a volume of gas, or 7 parts of water to 1

* This curve is a hyperbola, and the axes to which it is referred in the graph are not the normal axes of the hyperbola. The x-axis is the asymptote of one of the branches of the curve.

of gas. The gas will therefore equal 1/8 of a given volume of gas and water and the water will equal..... 7/8

At a depth of 166 2/3 feet, we shall have 2/6 volumes of gas to each volume (6/6) of water or 2 parts of gas to 6 of water. The water in each volume will therefore be.. 6/8

At the depth of 133 1/3 feet, there will be 3 parts of gas to 5 of water. The water will then equal..... 5/8

So, at 100 feet the water will equal..... 4/8

66 2/3 feet the water will equal..... 3/8

33 1/3 feet the water will equal..... 2/8

At the water level or 0 feet the water will equal.. ... 1/8

The next step in the progression would be the removal of the atmospheric pressure, which would result in the expansion of the gas to an infinite volume. As a necessary consequence, the water would be reduced to 0, or disappear, in an attempt to state it in terms of the combined volume of gas and water.

If now we plot the progressive decrease in the volume of water as we ascend the well, we shall obtain the following graph:

This diagram presents a simpler problem than the last and gives rise to a simpler equation as follows:

Let $x =$ pressure expressed in atmospheres

$y =$ number of volumes of water to each volume of mingled water and gas

$N =$ number of volumes of gas at atmospheric pressure to each volume of water

Then $x = Ny$ and $y = x/N$.

The locus is therefore a straight line and indicates that the ratio of the water volume to the combined water and gas volume decreases as we ascend the well from the plane of saturation in arithmetical progression.

Weight of gas and mineral content as affecting efficiency of gas lift. In making our computation of the resultant pressure due to the gas lift at the hydraulic level, we have considered the weight of the gas as negligible, basing our results solely on the weight of the water. This we may do for all practical purposes, since water is 500 times heavier than CO_2 at atmospheric pressure. Yet, to achieve mathematical accuracy, the weight of the gas would have to be taken into account, the more so since it

increases rapidly in weight by reason of the hydrostatic pressure as we descend the well, being at the depth of 200 feet seven times as heavy as at the surface.

The quantity of soluble salts in the water of a given well also affects the specific gravity of the water and would have to be taken into consideration where results of great accuracy are demanded.

Temperature is also a factor to be taken into consideration. In the foregoing computations it is assumed to have remained constant.

Finally, another correction must be made because of the fact that gas does not come out of solution in exact conformity with the theory supposed to govern its behavior. When the water flows from the mouth of the well we have assumed that it holds in solution but a single volume of gas at atmospheric pressure. Instead of this, it holds substantially more than a single volume, or, in other words, is supersaturated and gives up the gas that constitutes such supersaturation slowly, unless the water is shaken or agitated, when the process is accelerated, retaining it to a greater or less degree and for a longer or shorter period of time, depending, no doubt, upon the quantity and character of the mineral salts held by it in solution and the care taken to avoid violent agitation. This property is what makes it possible to furnish water supersaturated with carbonic acid gas for baths and for the patient to absorb the gas into his circulation; and this is generally believed to be its most important therapeutical characteristic.

Dr. Paul Haertl, of Bad Kissingen, probably the most accomplished expert in the methods of drawing, storing and using carbonated waters in the world, has invented a simple and convenient device to measure the degree of supersaturation and by its use it has been found that under favorable conditions the water may be supersaturated with gas to the amount of 85 per cent. of its volume at atmospheric pressure. It is quite obvious that this is a disturbing factor of substantial importance that tends to minimize the effect of the gas lift. To obtain an accurate result, therefore, it is necessary to take into account this capacity of mineral water to hold in solution for a time more than the theoretical volume of gas.

Percolating Mineral Water and Dry Gas Wells. Although it seems clear that the wells which have been drilled into the water bearing strata of the dolomite rock encounter a subterranean

stream of carbonated waters flowing northerly along the bedding planes which affords them a supply, it is none the less clear that the carbonated waters are found in places as percolating waters. This occurs in the Saratoga plateau, where they are found, after emergence from the rock, in a deposit of sand or gravel overlying the Hudson River shales and beneath impervious layers of clay and quicksand.* This deposit in which the waters percolate, being so much nearer the surface than the dolomite strata out of which they escape, and the pressure, consequently, being so much less, they cannot retain their full content of CO_2, but give it up in the form of free gas, which rises to the top of the water and is entrapped by the impervious clay strata and collects beneath them. So it has happened that wells driven through the clay immediately encounter free gas under considerable pressure, which rushes out of them with much force, sufficient, it is said, at times, to eject stones from the mouth of the well high into the air. In the natural course of events, this deposit of gas would be, after a time, exhausted; and, the pressure it exerted on the surface of the water being thus relieved, the water would rise in the well and act as a seal, and no more gas would escape from it, except through the influence of the principle of the Pohle air lift, which we have described.†

But, after the discovery of the dry gas wells, which were first found on the Lincoln Spring property, the natural course of events was disturbed by the operations of the Lincoln and Natural companies, both of which were continually seeking to increase their gas product. Numerous wells were drilled through the deposits in which the carbonated waters were percolating and into the rock strata, until the mineral waters were there encountered. The mineral waters came up through these wells naturally at first; and, when depletion had set in to such a degree that the hydrostatic pressure, aided by the natural gas lift we have mentioned, failed to produce them at the surface, the owners supplemented the forces of nature by a more efficient artificial gas lift, which brought them to the second stage of depletion. When this had been reached, deep well pumps were installed, the barrels

* Testimony of William C. McQueen in Hathorn v. Strong; Stenographer's Minutes, p. 116.

† Testimony of Prof. Kemp in People v. N. Y. C. A. Gas Co.: Sten. Min., pp. 217, 249.

being submerged 150 feet below the surface; and, when the State acquired the properties, in some, at least, of these wells, the water levels had been lowered to a point below the pump barrels. The continuance of the process would undoubtedly have brought the mineral water system to a third stage of depletion, when the deep well pumps, aided by the atmospheric pressure, could no longer have reached the water and it would have been necessary to lower the pump barrels to a greater depth.

This depletion had a curious effect upon the dry gas wells. The removal of so much water diminished the hydrostatic pressure to which the carbonated waters were subjected and this compelled the waters to give up a large part of their CO_2 content which, rising and collecting beneath the clay strata, formed a continuous supply for the so-called dry gas wells, while the pumping prevented the waters from rising and sealing them off in the manner we have described. In other words, it formed an immense natural separator in the deposit of gravel below the clay which separated the gas from the water and delivered the former free at the mouths of the dry gas wells.

When, by the stopping of the pumps, the forces of nature were left to operate without interference from man, the mineral water levels at once began to rise and continued to do so until the event occurred which would have occurred much sooner, except for the interference which has been mentioned — the rising water reached the bottoms of the dry gas wells and sealed off the gas, since which they have yielded no gas at all.

Extent of mineral water supply. There is general agreement among experts that the mineral waters of Saratoga are found in the strata of the Little Falls dolomite underlying the Utica shales. This has also been established by the actual experience of well drillers. It is also established, by many investigations and experiments, that not all the strata of the dolomite are filled with mineral water. Some are dry and others yield fresh water. The maximum aggregate thickness of the strata carrying mineral waters between the shale and the Potsdam sandstone is probably not more than forty or fifty feet. Assuming it to be 45 feet and the beds capable of holding water to the extent of 10 per cent. of their volume, a capacity at least double that which has been attributed to the Potsdam sandstone, they would have a storage

capacity approximating 1,500,000 gallons per acre of surface area, or 960,000,000 gallons for each square mile. The area beneath which it is possible mineral waters may be thus stored in the rocks is measurable by miles and these figures may aid in forming a conception of the whole amount thus stored.

This supply, large as it is, is by no means inexhaustible. Pumping from it at the rate of 500,000 gallons daily, a rate not much if any beyond that sometimes actually reached when all the gas companies were operating, would entirely exhaust the mineral waters in an acre of land in three days, or in 120 acres in a year, or in a square mile in 5 or 6 years. The operations of the gas companies were carried on, though perhaps not on so large a scale, for more than that period of time.

Supply continually replenished. The great depletion wrought by the pumping, which served to reduce the mineral water head to the extent of more than a hundred feet over a large area, would have been permanent if there had been no source of supply other than the waters at the time stored in the strata of the dolomite. Some eminent geologists believed the depletion to be permanent and entertained the opinion that measures of conservation had arrived too late to be capable of valuable results. Contrary to their expectations, however, the mineral water head has continued to rise ever since these measures were made effective; and at the end of the third year progress toward normal conditions continues.

It must be assumed, therefore, that there is a continuous flow at some point into the dolomite strata of saline carbonated waters, probably with a low relative content of calcium and magnesium carbonates or even without any of these substances, and that the carbonates are taken up from the beds of dolomite. It may be that the foregoing suggestions as to the direction of flow and the rate at which the carbonates of calcium and magnesium are dissolved from the rocks will aid in determining the location of the point where the emergence of the waters from other and probably lower formations into the dolomite takes place.

From the foregoing examination and study of the facts relating to the Saratoga mineral water system, the following propositions seem to have been established:

First. There is, at Saratoga Springs, a double hydraulic system of ground waters, the upper being the system of superficial fresh ground waters and the lower the system of saline carbonated mineral waters; and the two systems are separated from each other by impervious strata of clay and rock.

Second. The lower of these two systems, or the saline carbonated water system, is an artesian system, actuated by a head more or less distant from the district in which the mineral springs and wells of Saratoga are situated.

Third. The carbonated mineral waters flow in a subterranean stream or streams in the bedding planes and other openings in the strata of the Little Falls dolomite; and their course between Hathorn No. 2 and Hathorn No. 1, a distance of three miles, is in a general northeasterly direction.

Fourth. The Saratoga mineral waters probably enter the dolomite strata with a content of carbon-dioxide and sodium chloride. As they proceed in their course from southwest to northeast, they are subject to dilution from the upper fresh ground water system, and their relative content of chlorides is constantly decreasing.

Fifth. The mineral waters acquire their content of bi-carbonates of lime and magnesium from the strata of the dolomites through which they flow, and the ratio of their content of these bicarbonates to the chlorine content of the waters is continually increasing as the waters flow to the northeast.

Sixth. The content of sodium bicarbonate is not acquired from the same source as the chlorine content, nor is it obtained from the dolomite strata, but it is probable that it is produced by the action of some chemical re-agent which comes into the waters at different points and in an irregular way.

Seventh. The Saratoga fault is not the opening through which the waters come up from great depths bearing their content of chlorine and carbon-dioxide, but is probably a convenient exit by which the mineral waters escape from the strata of the Little Falls dolomite and flow to the surface as natural springs.

Eighth. The point where the waters emerge from great and unknown depths with their chlorine and carbon-dioxide content is at a considerable distance from the valley of the springs, and

it is probable that another fault west of the Saratoga fault affords the avenue by which they rise and flow into the dolomite strata.

Advantages and Disadvantages of Well Pits

The pit system, generally or universally employed in Europe for the use and control of wells yielding carbonated waters, is very important. It consists of a pit about the well, usually circular in form, sunk to a considerable depth below the ground water table, the well opening into the centre of the pit.

The water flowing into the bottom of the pit fills it up to the height where a condition of equilibrium is established. In the course of nature, where the waters are supersaturated with carbon dioxide, an atmosphere of carbon dioxide accumulates upon the surface of the water in the pit, expelling the atmospheric air and filling the pit. The waters may be permitted to flow off gently, at the highest level, so as to insure a constant replenishment of more highly carbonated waters at the bottom of the pit and to guard against deterioration from stagnation. The water standing highest in the pit gradually loses a portion of its carbon dioxide content until the point of complete saturation at the atmospheric pressure is reached, the excess of gas rising to the surface of the water. We then have the pit containing carbonated waters, protected from the air by an atmosphere of carbon-dioxide. As we proceed below the surface, the degree of carbonation increases, due to the increasing pressure of the superincumbent water. When we reach a depth of about 32 feet, the water contains two volumes of carbon dioxide at atmospheric pressure.

We may thus draw from the pit a water supersaturated with CO_2 to any desired point, up to a total gas content of two volumes at the atmospheric pressure, by drawing it from the proper depth below the surface. Only enough water will flow out of the well into the pit to make good the quantity withdrawn from the pit, and its outflow will be accomplished in the most gentle manner possible, and agitation which might cause the water to give up its carbon dioxide will be reduced to a minimum. In this way, unnecessary drafts on the mineral water supply are avoided, and the storage of the waters in the system provided by nature

for the purpose is accomplished. Moreover, if an occasional demand arises for a supply of water for a short period of time, beyond the normal flow of the well at the surface of the ground, there is no other way in which it can be met with as little depletion of the well or general disturbance of the hydraulic system.

When the waters of the well flowing from the mineral water vein are highly carbonated and water is drawn from the pit more rapidly than the mineral water vein can supply it, a general cone of depression in the contiguous ground waters will result, causing an inflow of waters that are not carbonated. These mingling with the highly carbonated waters will take up part of their carbon dioxide content which would otherwise pass off into the atmosphere, thus increasing the quantity of water sufficiently carbonated for bathing purposes.

If it is at any time desired, the well may be made to spout, in case it has a sufficient gas content to operate as a gas lift, by sealing into the well a small pipe through which the normal flow of the well will cause the waters to ascend fast enough to keep the waters and free gas commingled until they escape from the mouth of the well. This can be quickly adjusted and removed at pleasure.

These are very great advantages where the demand is irregular and for a large quantity of water of a moderate degree of carbonation for a few hours, with considerable intervals, when no water, or a negligible quantity, is required. Such conditions attend the use of waters for bathing.

If the demand is for more highly carbonated waters for drinking, these advantages are less obvious. There the use of the pit might be fatal to the accomplishment of the purpose. A water containing three volumes of CO_2 at atmospheric pressure, for which there exists a commercial demand, could not be supplied without artificial appliances; for a pit of sufficient depth could not well be constructed. Moreover, in bottling waters the use is more regular, proceeding at a constant and moderate rate throughout the entire 24 hours.

It would seem, therefore, that for drawing waters for drinking and bottling, the advantages of the pit system may not be so great; and one important consideration, due to conditions per-

haps peculiar to the springs at Saratoga, is worthy of note in this connection as liable to offset, in some cases, all possible advantages.

Attention has already been called to the fact that the mineral water head is artesian in character, and acts upon the head of the contiguous superficial fresh waters through the springs, and is in turn acted upon by it. In this way surface waters may at times flow into the mineral water wells and springs, perhaps bringing in pathogenic germs with them. In this way we suppose waters carrying H_2S obtain entrance to the springs and impair them. These fresh or sulphur bearing waters probably gain entrance to the wells in the upper part of them and are more likely to appear where the mineral water head is depleted or the fresh, surface waters are relatively high.

The operation of the well under the influence of the gas lift is a great safeguard against pollution from such sources. This can readily be understood when we consider the condition of the well under such circumstances. In a well supplied by waters containing five volumes of CO_2 the plane of saturation is encountered at a point about 140 feet below the level of the water in the well. At this point and below it, there is no difference whether the well opens into a pit or flows by the gas lift; but at all points above there is a difference, constantly increasing as you proceed toward the surface.

Under the conditions represented in the well figured upon page 104 the water level in a pit would stand ten feet below the surface of the ground. Fresh or impure waters under a head above that would flow into the well at any point, if the well opened into a pit — but if the well were flowing by the gas lift, from a point not far above the plane of saturation the pressure within the well would be greater than that outside; and, if an opening existed anywhere above that point, the waters would tend to flow out through it and waters outside could not flow in.

If, for instance, such an opening should exist at "c" half way between "a" and "b," and polluted waters outside stood there ready to flow in, and if their head was no higher than the ground water table about the well or below that point, their maximum inward pressure at "c" would be equal to a column of water 70 feet in height. The outward pressure on the well of the waters

standing in the well, if the gas seal was effective, would be the same at the same point, under the same head. But, if the column of water in the well became lighter, in consequence of CO_2 being given off, so that its specific gravity at "a" should be reduced one-half, the pressure at "c," half way between "a" and "b" would, without allowance for friction, be less than that at "b" only by the back pressure of a column of water inside the well and below that point whose average density or specific gravity would be less by ¼ of ½ than the density of uncarbonated water, or ⅞ as heavy as uncarbonated water and capable of exerting a back pressure at "b" due to their weight, of ⅞ of the pressure of a normal water column of 70 feet in height, or equivalent to a normal water column 61.25 feet high, thus resulting at "e" in $140 - 61.25 = 78.75$ feet head, as against a head of 70 feet impelling water to enter the well In other words, at "e" waters outside the well could not flow into the well unless they had a head nearly 20 feet higher than the ground waters about the well.

From this point to the surface the advantage of the pressure in the well for the exclusion of water tending to flow into it would constantly increase, until, when the water table was reached, the pressure in the well would be 35 pounds and the outside pressure zero.

It is easy to see that this increase of pressure within the well may be, under certain circumstances, of the greatest benefit as a protection from contamination by surface waters; and, in the Saratoga basin, from waters flowing in the shale and carrying sulphuretted hydrogen, which are all the time seeking to flow into the upper parts of some of the wells.

Memorandum in Relation to the Drawing and Storage of Mineral Waters

Carbonates of lime, magnesia and iron are not highly soluble in water, but carbon dioxide dissolved in water increases its capacity to dissolve these substances and hold them in solution, doubtless by converting them into more soluble bicarbonates. This capacity increases with an increase in the amount of the carbon dioxide in solution. Mineral waters that come from a considerable depth,

where they are under pressure and contain more than the amount of carbon dioxide which they are capable of holding in solution at the normal atmospheric pressure, often hold in solution these carbonates in quantities too great to be retained when, after having been brought to the surface, the pressure is relieved and the carbon dioxide passes off into the atmosphere. Accordingly, such waters, when brought to the surface, first lose their carbon dioxide and then become turbid from the precipitation of a portion of their solid contents; and the substances thus precipitated finally sink and form a sediment at the bottom of the receptacle that contains the waters.

The mineral waters of Saratoga illustrate this characteristic in a remarkable way. Some of these waters hold in solution at the bottom of the wells as much as five and one-half volumes of carbon dioxide at the normal atmospheric temperature and pressure. When they come to the surface, over eighty per cent. of the gas is given off and the process of precipitation begins at once. This has always made it difficult to bottle the waters or to store them for bathing. If stored for the latter purpose in open tanks, they soon lose their gas and precipitate part of their mineral content and become muddy and less agreeable for use. In this particular they do not differ from similar waters elsewhere. The same trouble has been experienced at Nauheim.

Where wells have a limited flow and, during that relatively brief part of the day when baths are taken, the water is used at a greater rate than the normal rate of flow, the storage of waters during the remainder of the day, or some part of it, is necessary to meet the demands of the busy hours. It therefore becomes a matter of great importance to find some method of obviating the tendency to precipitation when mineral waters are stored.

The precipitation in storage tanks can be prevented by a system of storage under pressure. The waters can then be delivered to the bather with their entire mineral and gaseous content; and, although the process of precipitation will at once begin when the waters are drawn, yet as it is not an instantaneous process, the bather will have the benefit of a supersaturated solution and escape in a measure the unfavorable impression due to drawing muddy water for a bath.

To store large quantities of water under heavy pressure calls for large tanks or receptacles, and to obtain such as are able to withstand heavy pressure from within is increasingly difficult as the size of the receptacle increases. It may therefore, be advisable to make use of several smaller receptacles, which can be used as a unit and so arranged as to be as convenient as a single receptacle of the aggregate capacity of all of them.

The maximum amount of carbon dioxide in any of the Saratoga waters, according to Professor Kemp, is five and one-half volumes. The average amount, however, is less, perhaps not over three and one-half volumes, and to enable the water to hold this in solution, a pressure of about fifty pounds to the square inch is required. Such a pressure will not only enable the water to hold in solution all its carbon dioxide, but will at the same time prevent the precipitation of its carbonates of lime, magnesia and iron and be adequate for all purposes.

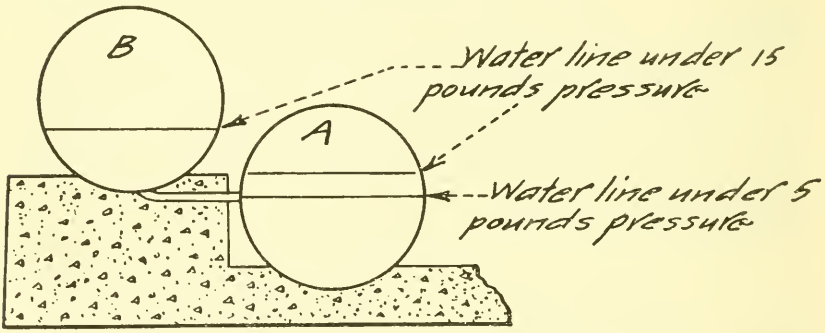
A cylindrical receptacle, four feet in diameter, will contain 93.456 gallons for each foot in length. The capacity in gallons of a cylindrical receptacle of any other size can easily be computed by multiplying the square of the radius of its base expressed in feet by the constant 23.56.

In order to draw the water entirely out of the storage system, without admitting air, it will be necessary to employ the expansive force of carbon dioxide; and this can be done by first filling the system with carbon dioxide at the normal atmospheric pressure. If this is done and the carbonated waters are then pumped into the receptacle until a pressure of three and one-half atmospheres is reached (or the normal atmospheric pressure plus 2½ atmospheres), the gas in the receptacle will be compressed until it occupies only two-fifths of its original volume and the remaining space will be filled with water. The capacity of a four-foot cylinder for water will, therefore, under the conditions assumed, be 56.07 gallons for each lineal foot and the constant will become 14.14 instead of 23.56.

The foregoing computations are based on a uniform temperature of 18 degrees C. A wide deviation from this temperature will make important differences in the pressure required and to maintain constant conditions in other respects it is important to

maintain a constant temperature. This may be done by sinking the receptacles into the ground, but will lead to difficulties in their management from the difficulty of access to them. Fortunately, nature has provided a method of accomplishing the same result in a much more convenient manner in the high bluffs composed of shale or slate, at the Geysers, through which Coesa creek has eroded its channel into which may be quarried an ample chamber in which the receptacles may be so installed as to render every part of them easily accessible. Here they may be laid down on their sides and arranged one above another so that the contents of all may be drawn from the lowest of the series.

The following diagram will illustrate the manner in which two receptacles may be arranged and the method of connecting them in order to accomplish the desired result.



In filling the lower of two receptacles (A) the gas will be compressed and partly driven into the upper one (B) until the lower is half full of water. By this process, the pressure will be raised to the normal atmospheric pressure plus five pounds, or to a total pressure of twenty pounds. Continuing the process, the water will rise in "A", sealing off the gas and preventing its further escape, until, when the pressure reaches fifteen pounds in addition to the normal atmospheric pressure, the volume of gas in "A" will be only one-third that of the water and "B" will be one-third full of water. (This disregards the slight difference due to hydrostatic pressure in consequence of one receptacle being elevated above the other.)

In the same way, continuing the process until a pressure of 3½ atmospheres is obtained, we shall have a gaseous content of 2/7 the volume of the receptacle and water equal to

5/7 of the same, or a storage capacity for water equal to 66.75 gallons to each lineal foot of a cylinder four feet in diameter under that pressure.

The result will be the same, so far as the amount stored is concerned, as if one large receptacle were employed and each of the two smaller ones will have an adequate quantity of gas to act as a cushion and to expel by its expansive force the liquid content.

In this connection, it should be considered that if water containing less than 3½ volumes of gas is pumped into the receptacle under a pressure of 3½ atmospheres, it may take into solution the whole or part of the gas with which the receptacles were originally filled; and the gaseous contents of the receptacles, required for elasticity, may thus be lost. To obviate this difficulty, provision should be made for supplying to the receptacle an additional quantity of gas; and the receptacles should be provided not only with pressure gauges but also with water gauges, to enable the amount of water contained in them at all times to be seen.

In this connection, also, should be mentioned the obvious desirability of securing and storing the carbon dioxide which comes to the surface with the waters. It will be required, constantly, for use in connection with any storage system; and it will be a matter of no great difficulty to secure it in sufficient quantities for use in connection with the waters utilized for bathing, as well as the bottled waters.

Closely connected with the question of storage is another question of equal importance, viz., that of the method of drawing mineral water from the well. As the water rises in the well and is permitted to flow under natural forces from the mouth of the well, it is, for a considerable distance below the surface, constantly losing its carbon dioxide and with it its ability to hold in solution its solid content. When it flows from the mouth of the well, it is not in the same condition as when stored in the rocks but has already suffered deterioration. Whether complete restoration can be effected by its immediate recarbonation under pressure may be questioned. It seems certain that there will at least be a loss of its radium emanation when it loses its original gaseous content.

It seems much more reasonable, therefore, to secure the waters

at a point below the plane of saturation by carbon dioxide and to place them immediately under pressure and keep them under pressure until delivered to the storage tank, thus affording no opportunity for the escape of carbon-dioxide and no opportunity for the precipitation of the solid contents. This is capable of satisfactory accomplishment by means of a deep well pump whose barrel will be submerged at least 75 feet below the surface of the water in the well. By this means the waters may be secured and stored in their natural condition.

To obviate the precipitation by bottled waters of their solid contents, recourse has been had in the past to different expedients. A device was invented for bottling the waters without permitting them to come into contact with the atmospheric air. This proceeded upon the theory that the precipitation was due to oxidation; but its real efficacy depended upon the immediate confinement of the waters in bottles under a considerable pressure, which prevented the escape of their carbon dioxide content and preserved their power of dissolving the carbonates of the alkaline earths. Another expedient was injecting into each bottle a sufficient quantity of citric acid to convert the less soluble carbonates into more soluble citrates.

The waters of the Reservation are all bottled under the supervision of the State. Most of them are bottled in the condition in which they flow from the mouth of the well. The waters of two springs, however, are permitted to precipitate the excess of solid carbonates which they are unable to hold at the normal atmospheric pressure before bottling. In this way the water remains clear, and no loss of the more soluble salts is sustained; but there is a partial loss, principally of carbonate of lime. It is believed that this is rather an advantage than otherwise in the case of waters that are to be used upon the table and drunk freely as a beverage.

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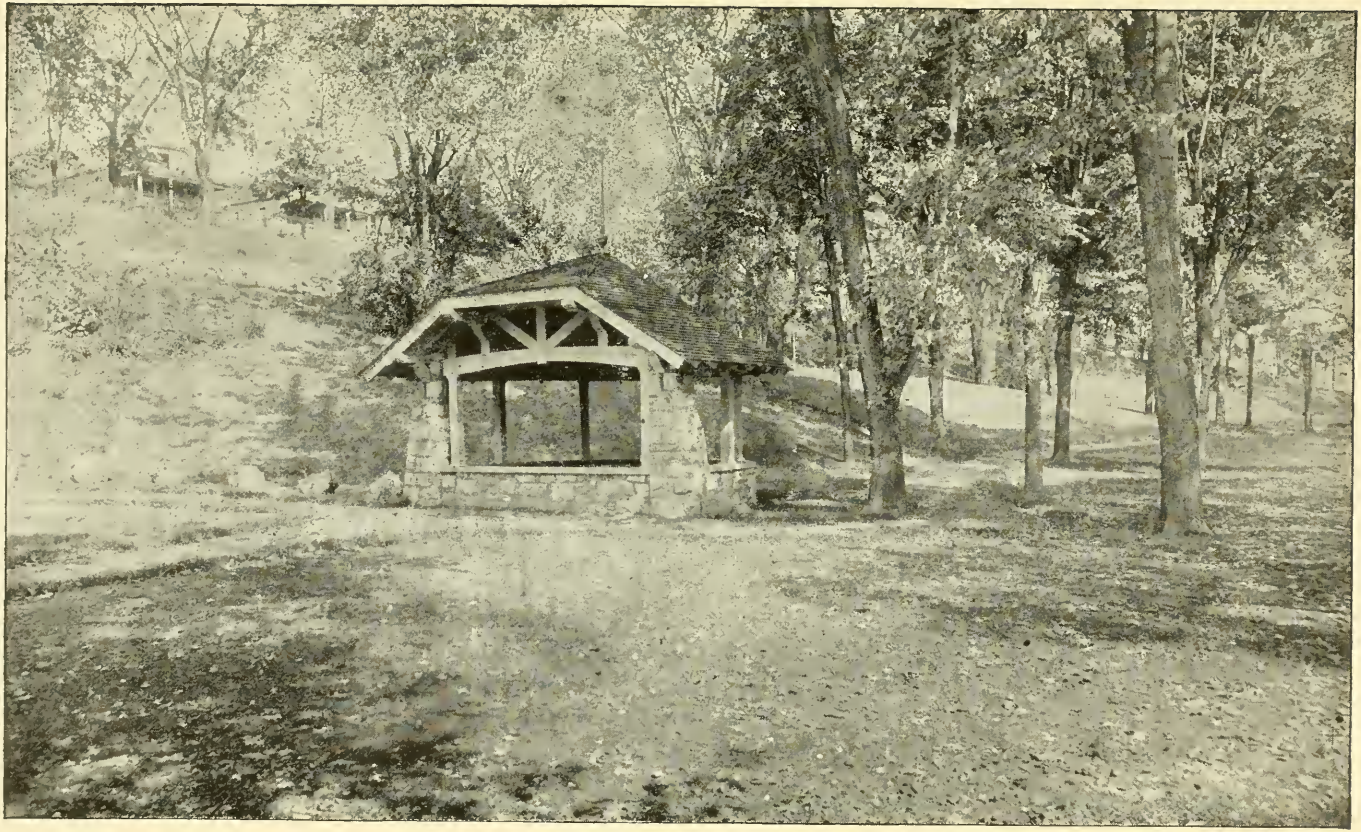


Pavilion in High Rock Park, Sheltering the Historic High Rock Cone of Tufa, a Landmark for Centuries

Eastern End of Interior of Hathorn Building Showing Pyramid of Bottled Waters

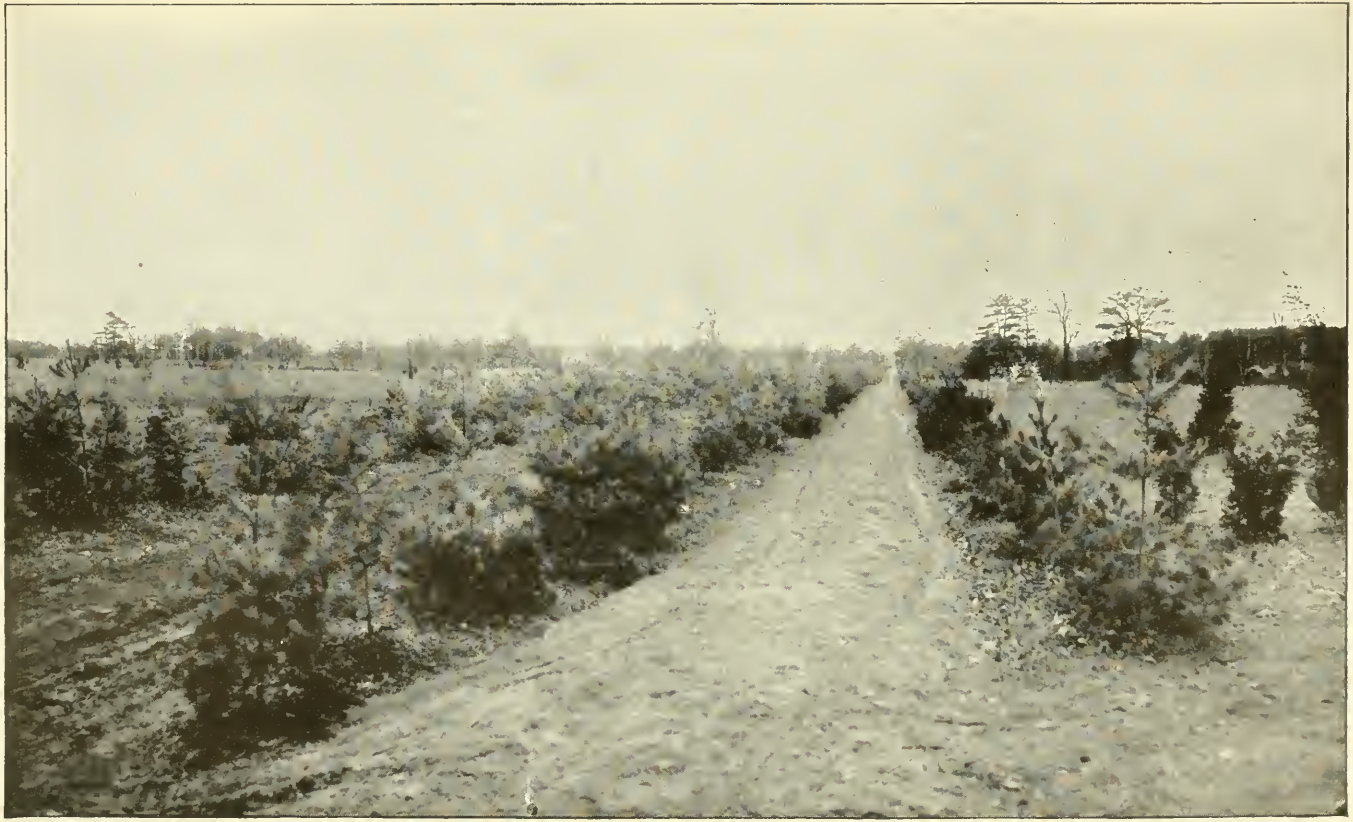
Bacteriology Room of State Reservation Laboratory, Hathorn Building

Water Analysis Room of State Reservation Laboratory, Hathorn Building

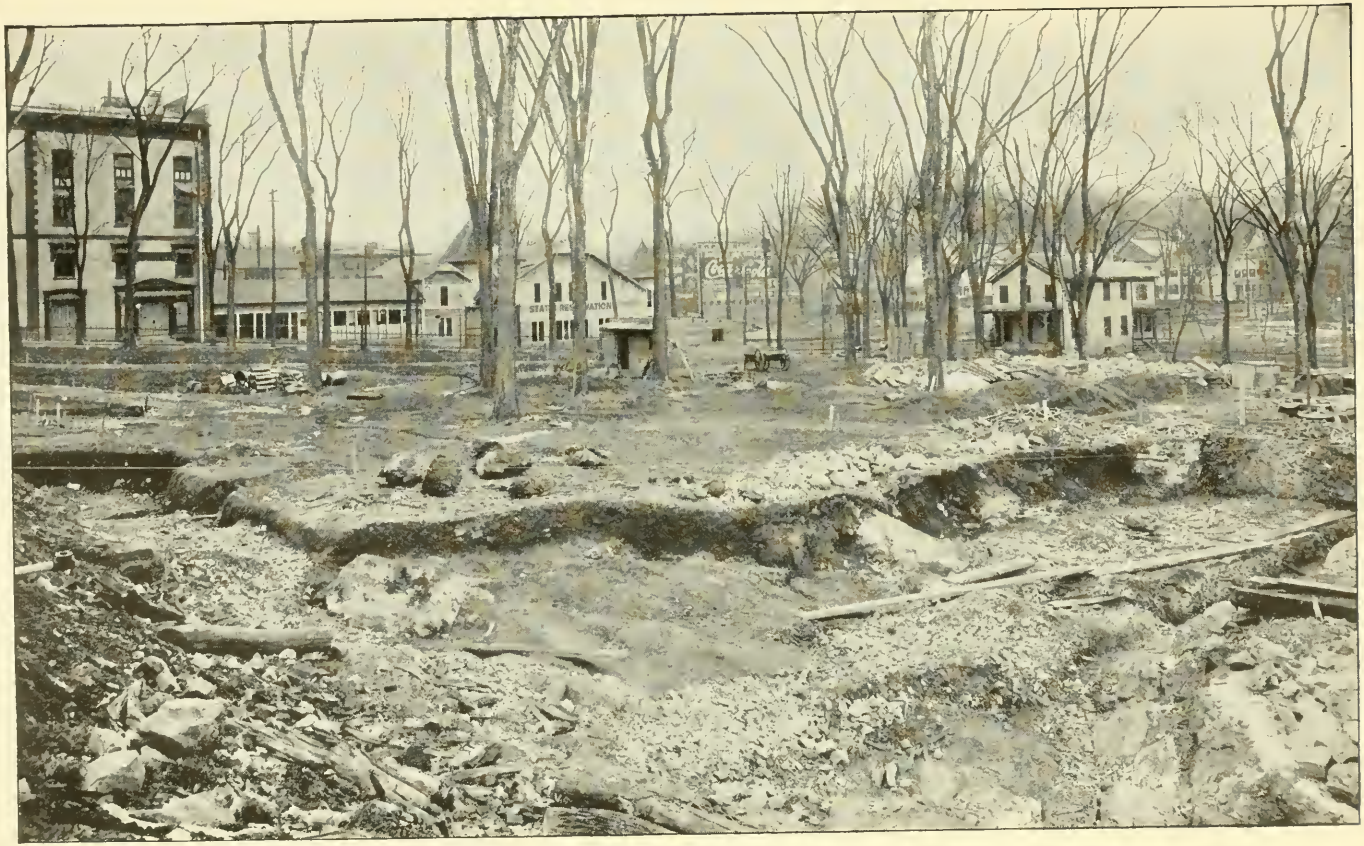
Draughting Room, Engineering Division, Hathorn Building

Motor Truck at Geyser Bottling Works

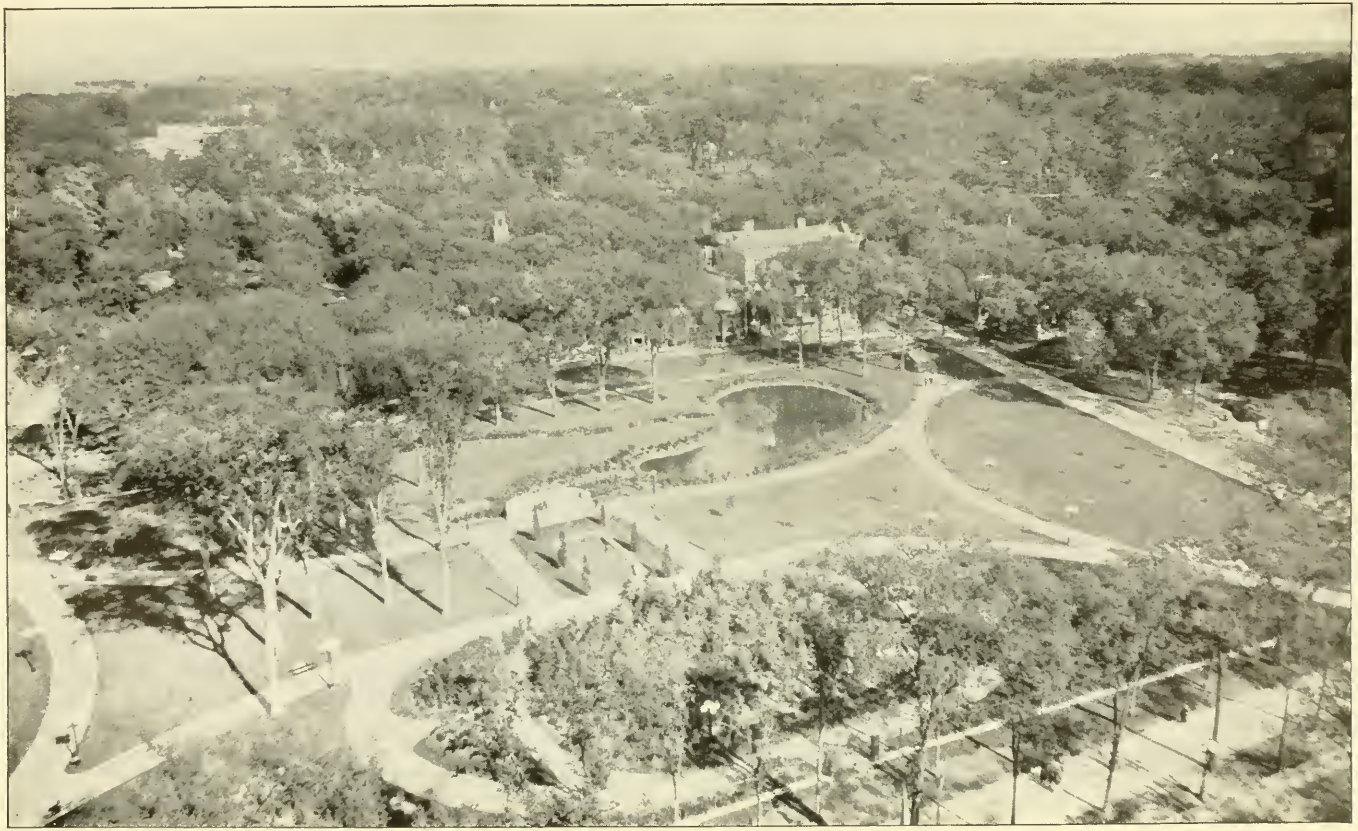
Bath House in Lincoln Park, Early Winter, 1914



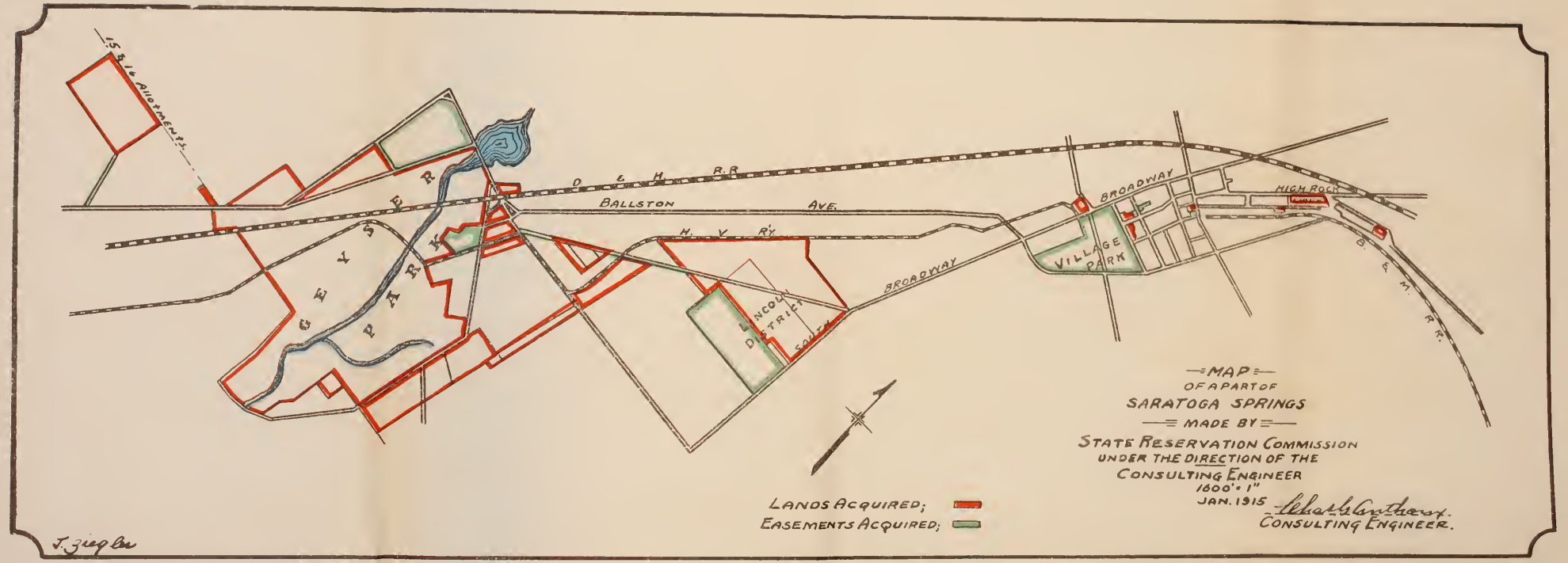
Four Rows of Pine Trees One Mile in Length, Connecting Lincoln and Geyser Parks, the Pine Promenade



Dolomite Upthrust on West of Geologic Fault Uncovered During Landscape Work in Congress Park, 1913

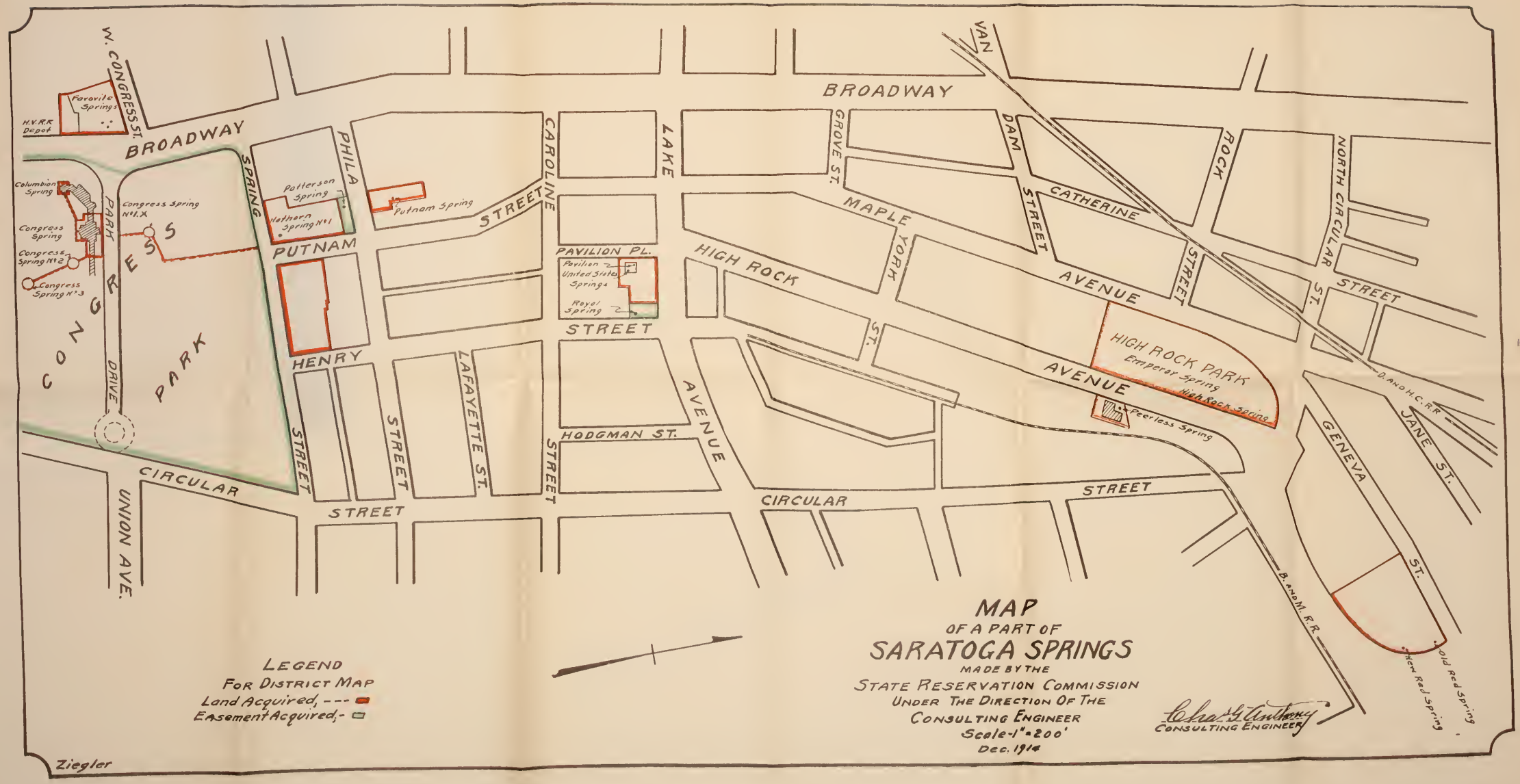


Bird's-eye View of Congress Park from the West, Showing the Green Mountains in the Distance and the Roof and Chimneys of the Casino, Formerly Canfield's Club House



MAP
OF A PART OF
SARATOGA SPRINGS
MADE BY
STATE RESERVATION COMMISSION
UNDER THE DIRECTION OF THE
CONSULTING ENGINEER
1800' = 1"
JAN. 1915 Edward H. Gruthers.
CONSULTING ENGINEER.

T. Zieglbe



LEGEND
FOR DISTRICT MAP
Land Acquired, ---
Easement Acquired, -

MAP
OF A PART OF
SARATOGA SPRINGS
MADE BY THE
STATE RESERVATION COMMISSION
UNDER THE DIRECTION OF THE
CONSULTING ENGINEER
Scale-1"=200'
Dec. 1914

Edward G. Anthony
CONSULTING ENGINEER

Ziegler

MAP
OF
GEYSER
AND
LINCOLN PARKS
WITH
PINE PROMENADES
CONNECTING.

MADE BY THE
STATE RESERVATION COMMISSION
UNDER THE DIRECTION OF THE
CONSULTING ENGINEER
SCALE 200 FT TO AN INCH
JANUARY 1915

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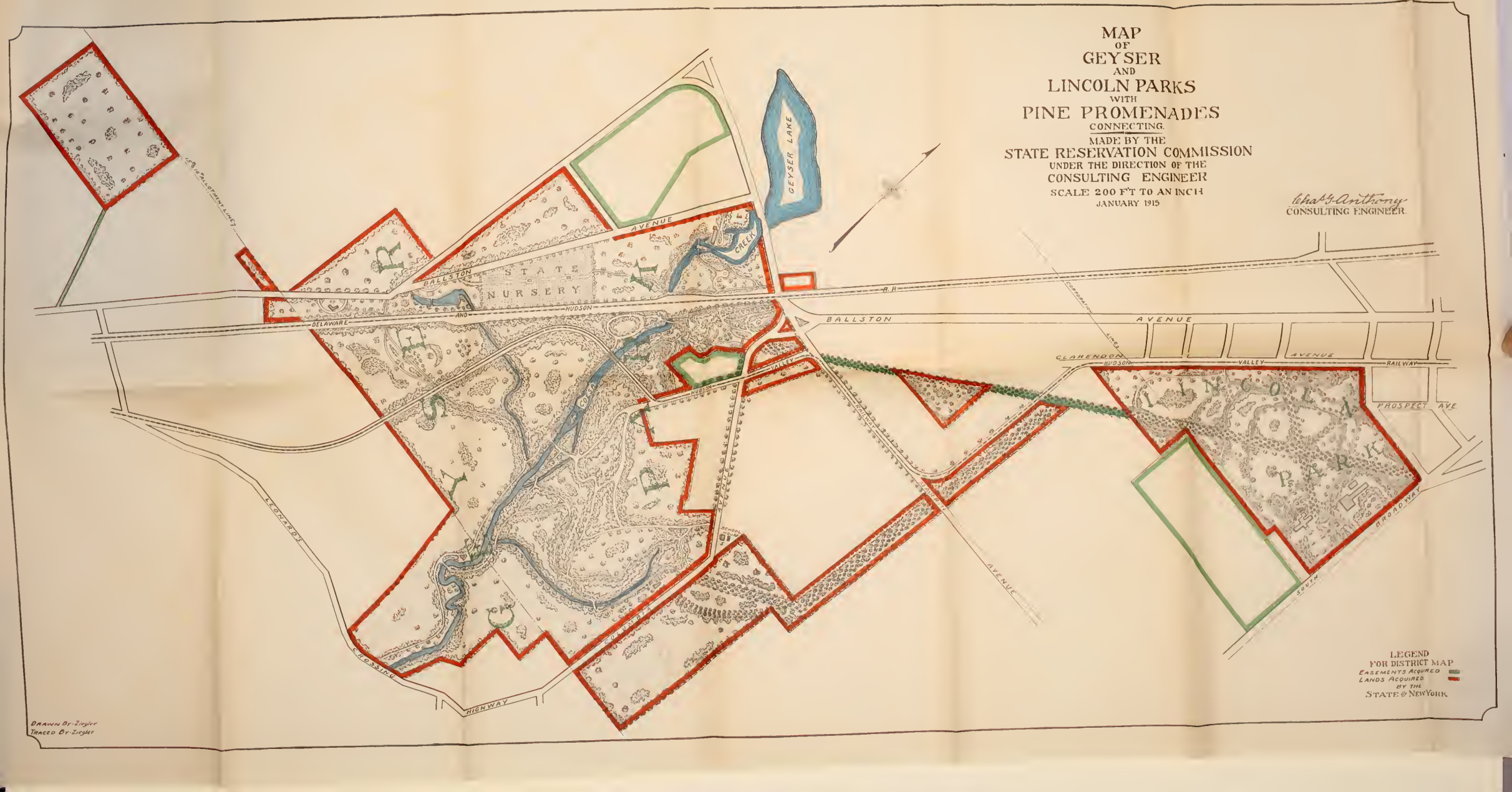
CONSULTING ENGINEER.



LEGEND
FOR DISTRICT MAP
EASEMENTS ACQUIRED
LANDS ACQUIRED BY THE STATE OF NEW YORK

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